BARN OWLS AND MAJOR ROADS:

results and recommendations from a 15-year research project

David J Ramsden

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Front cover picture: Stuart Dawber

Index

Road verges are an important wildlife resource   Photo: Stuart Dawber

When individual Barn Owls encounter a major road they are very soon struck by traffic
Photo: Stuart Dawber

Executive Summary

- Britain's Barn Owl population suffered a substantial decline throughout most of the 20th century and the proportion of recorded deaths attributed to road traffic increased from 6% in 1910-54, to 50% in 1991-96.
- Of all owl and raptor casualties found on major roads, Barn Owls are by far the most frequent victims.
- On minor roads Barn Owls are fifty-seven times more likely to be seen alive than found dead. Conversely, on major roads Barn Owls are three times more likely to be found dead than seen alive.
- In Devon, a county with relatively few major roads, the probability of juvenile Barn Owls encountering a major road is < 25%.
- 72% of Barn Owls which are known to have encountered a major road (n=62) were killed during the encounter.
- When individual Barn Owls encounter a major road they are very soon struck by traffic.
- Barn Owls killed on major roads are not those that would have died anyway. Rather, major roads primarily kill older owls that should have survived.
- It has been suggested that road victims are often under-weight or weak individuals which are going to die anyway. However, studies that have quantified the bodily condition of road casualties have shown that this is not the case.
- New major roads cause the loss of local Barn Owl populations and the long-term absence of resident Barn Owls within at least 0.5 km either side.
- Barn Owls are not able to disperse along major roads because they become road casualties too quickly.
- Major roads act as partial barriers to Barn Owl dispersal and may have played a significant part in Barn Owl population decline in parts of Britain.
- **The presence of major roads in rural England has removed Barn Owls from an area of between 8,100 and 16,200 sq km and depleted the population over an area of roughly 48,600 sq km - 40% of the total area of rural England.**
- Major roads cause the complete absence of breeding Barn Owls within 0.5 km either side of the road, severe depletion of their population within 0.5-2.5 of the road and some depletion within 2.5-8 km of the road. It is not until 25 km from a road that no effect of its presence on Barn Owl populations can be detected. Since, almost the entire area of lowland Britain lies within 25 km of a major road it is highly probable that **almost the entire British Barn Owl population is to some extent suppressed by the presence of major roads**.
- On balance, road verges are an important wildlife resource and current developments in management practice are aimed at increasing their suitability for wildlife.
- Measures to reduce the adverse impacts of major roads on Barn Owls in Britain (mitigation measures) have not been generally adopted by road designers and managers.
- The main *guidance documents* and *good practice guides* on reducing the impact of roads on wildlife have failed to recommend mitigation measures for Barn Owls.
- Within its Biodiversity Action Plan, the Highways Agency acknowledged the extent of Barn Owl decline and stated its intention to *implement appropriate actions* from this report.
- Major road deaths have more impact on Barn Owls than any other animals (due to their rarity and the frequency with which they are killed).

Continuous hedges and / or lines of trees should be created adjacent to the metalled surface along both sides of major roads
Photo: David Ramsden

The UK government should implement changes in agricultural policy that result in a dramatic improvement in the quality and quantity of Barn Owl habitat, principally rough low-intensity grassland,away from major roads
Photo: David Ramsden

Recommendations

1. The UK government should implement changes in agricultural policy that result in a dramatic improvement in the quality and quantity of Barn Owl habitat, principally rough low -intensity grassland, away from major roads.

2. The UK government should implement changes in transport policy that result in re duced dependence on road transport and avoid the need for additional major roads.

3. In order to obstruct low-level flight across carriageways, continuous hedges and/or lines of closely spaced trees (>3 metres high) should, wherever possible, be created adja cent to the metalled surface along both sides of major roads. This is especially important where roads are level with, or raised above, the adjacent terrain.

4. Owls and Birds of Prey should not be encouraged to hunt along major road verges except where foraging habitat is provided behind continuous screens (rec. 3).

5. Areas of rough grass, which are likely to support small mammals, should only be provided near roads if they can be sited behind continuous screens (rec. 3).

6. In areas where continuous screens (rec. 3) are not provided and the loss of verge grassland is acceptable, permanent ground cover such as dense bramble or gorse should be maintained across the entire width of both verges, in order to reduce the attractiveness of the verge to Barn Owls. This is especially important where roads are level with, or raised above, the adjacent terrain.

7. Barn Owls should not be encouraged to nest within 1 km of any major road unless the roads in question are protected by continuous screens (rec. 3) or sunken >3 met res below the level of the adjacent terrain. Ideally Barn Owls should not be encouraged to nest within 3 km of a major road.

8. New unscreened major roads should not be built in rural areas where major roads are currently absent and Barn Owls still resident within 25 km. This includes motorways, dual carriageways, modern two/three lane "A" roads and local bypasses.

9. Further research should be carried out in order to determine the effectiveness of continuous screens (rec. 3) and the effectiveness of permanent dense ground cover (rec. 6) in reducing Barn Owl deaths along major roads.

10. Highway maintenance staff should be trained to identify bird species and required to systematically record roadside casualties.

Photo: Mike Read

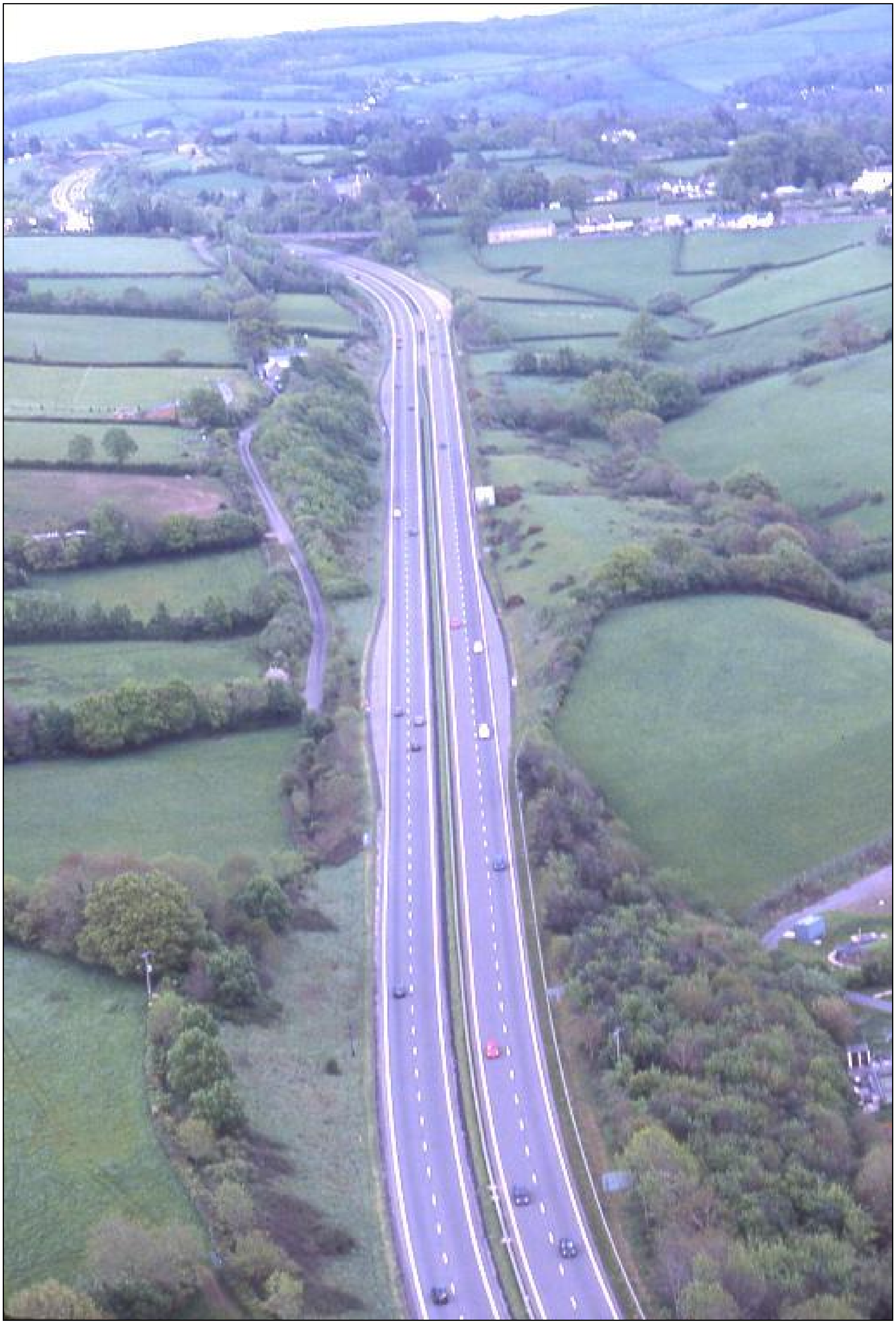


Photo: David Ramsden

Descriptive Summary – Barn Owls and Major Roads: effects and solutions

Description of the effects of individual major roads on local Barn Owl populations

Due to the high density of minor roads and the large size of their home ranges, Barn Owls are frequently exposed to relatively slow-moving vehicles on minor roads but are generally unaffected by them, possibly because they learn to avoid frequently-encountered minor hazards. Whilst a major road is being constructed through home ranges, the birds are unlikely to be affected unless the development involves the removal of occupied nest or roost sites, such as an agricultural building or hollow tree. However, once the road is opened, resident birds are exposed to the risk of collisions with vehicles whilst making their normal nightly sorties within their home range. Newly opened major roads are more dangerous than traditional minor roads because they lack tall roadside cover, such as hedges and this enables the birds to fly across the carriageway within vehicle height. In addition, the speed and frequency of passing vehicles is much greater. As soon as a new major road is opened accidental deaths of Barn Owls begin.

Almost all major roads have wide verges and by about two years after construction these areas are normally dominated by rough grassland supporting populations of small mammals – the Barn Owl's prey. At this stage any planted trees or shrubs are still too small to reduce the chances of birds flying across the carriageway within vehicle height. Any Barn Owls that encounter major roads and are not killed immediately, may start to forage along the verge, but do not survive for long. All Barn Owls that hunt along major road verges are bound to fly over the carriageway sooner or later and half of all casualties are found either on the hard shoulder, in the gutter, or on the nearside edge of the slow lane. Thus, major road deaths are a combination of purely accidental deaths of birds moving across the countryside and deaths of birds fatally attracted to hunt the verges.

As major road verges mature, the growth of scrub/tree plantations and the regular mowing of small areas reduce the amount of rough grassland. However, along the majority of major roads scrub/trees are usually too far from the carriageway to force birds to fly higher whilst crossing, there are ample areas of fatally attractive permanent rough grass and Barn Owls are killed every year.

In the nesting season (March-August) all adult Barn Owls whose nest site is within 0.5 km are almost certain to be killed and those within 1 km are highly likely to be killed. Outside the nesting season, adult Barn Owls whose main roost site is within 0.5 km are almost certain to be killed, birds within 2-3 km are highly likely to be killed, but birds beyond 5 km are most unlikely to be affected. During the period when young Barn Owls are dispersing from nest sites (August-November), roughly 40% of birds dispersing from within 1 km of a major road will be killed, about 20% of birds dispersing from 12 km will be killed, but birds dispersing from 25 km are most unlikely to be affected.

Description of the effects of the major road network on the wider Barn Owl population

Resident Barn Owls are normally absent within 0.5 km of major roads and are highly unlikely to be present within 1 km. Due to their increased foraging range in winter, extending to 3-5 km, Barn Owl populations within 3 km of major roads are highly likely to be permanently depleted. Lines of Barn Owl absence (1-2 km wide) and depletion (c. 6 km wide) probably exist along all major roads in rural Britain. Based on a total length of approx 8,100 km (in rural England) it can be estimated that the presence of major roads has removed Barn Owls from an area of between 8,100 and 16,200 sq km and depleted the population over an area of roughly 48,600 sq km - 40% of the total area of rural England. However, any assessment of the impact of the major road network must also consider: suppression of the wider Barn Owl population resulting from increased juvenile mortality, the effect of encirclement of land by major roads and the fragmentation of populations resulting from the barrier effect of major roads.

All populations are subject to turnover: each year a proportion of adults die and young birds are recruited into the adult population. For a population to be stable year-on-year, the number of young recruits must match the number of adults lost and it has been shown that the survival rate of young Barn Owls is the most powerful life-cycle parameter (ie. it influences overall population size more than factors such as adult survival or the number of eggs laid). In Devon, a large rural county with few major roads, roughly 200 young must survive annually in order to maintain an adult population of 300 pairs. About 700 young fledge from nests each year and most die from starvation. Many others die from a wide variety of relatively minor mortality causes. Of those birds that survive the early stages of independence, up to 175 encounter a major road during dispersal and up to 125 of these are killed.

In Devon, major roads kill up to 18% of all the young Barn Owls produced in an average year. In counties with a higher concentration of major roads, such as those surrounding London, Birmingham and Manchester, it is probable that the proportion of all juveniles that become major road casualties is much higher. Not only do major roads annually kill a significant proportion of all juveniles, the individuals they kill are those that have outlived most of rest, who succumbed to other mortality causes. On average, at every Barn Owl nest site, each of the adults will die every 2-3 years. If single juveniles do not arrive often enough breeding will not occur annually and eventually the site will become unoccupied.

Because major roads act as partial barriers to dispersal, the wider population is also vulnerable to fragmentation. At a local level, this may be most apparent where there are blocks of land encircled by major roads (for example in the Home Counties). Encircled blocks that are large enough to contain one or more entire home ranges (at least c. 20 sq km) may contain resident breeding birds. However, it is highly unlikely that any of their young could disperse out of the block. Conversely, if the block became unoccupied, perhaps as a result of severe winter weather, the chances of birds moving into it are small. Fragmentation also affects wider populations due to differences in the productivity of adjacent populations and the interaction between them.

Some landscapes are more suited to Barn Owls than others. For example, in areas with a good food supply and ample nest sites, population density, nesting success and survival are greater than in areas of poor habitat. Populations in areas of poorer habitat, where mortality exceeds productivity (sink areas), are only maintained by the annual arrival of juveniles from more productive (source) areas. Where a major road passes between them, the effect will be to greatly reduce the movement of birds from source areas to sink areas. In this way major roads could contribute to the decline of populations across vast land areas, vice-counties, counties, or even regions.

Across a distance band of 0-25 km, the effect of major roads on the Barn Owl population varies from complete absence (<0.5 km), to severe depletion (0.5-1 km), some depletion (1-3 km) and reducing suppression (3-25 km). In addition, the populations of areas that are isolated by major roads and other barriers to dispersal, where mortality exceeds productivity, will be suppressed, irrespective of distance. Almost the entire area of lowland Britain lies within 25 km of a major road. It is therefore highly probable that almost the entire British Barn Owl population is to some extent suppressed by the presence of major roads in the environment.

The targeting of Barn Owl conservation resources

The UK government is spending significant public funds on agri-environment schemes, partly aimed at reversing the decline of farmland birds through habitat restoration. Wildlife conservation organisations, including owl conservation groups, have also deployed considerable resources. Current initiatives include the provision of grants and advice to landowners on the Barn Owl's habitat needs, often focussing on the maintenance and creation of rough grassland and the voluntary erection of Barn Owl nestboxes. However, in targeting such work, little account is taken of the presence of major roads in the environment.

Unless the roads in question are unusually safe, Barn Owls should not be encouraged to nest within 1 km of any major road. For the adult pair to stand a reasonable chance of winter survival they should not be encouraged to roost/nest within 3 km of a major road, ideally 5 km. For the dispersing young to stand a reasonable chance of survival, adult pairs should not be encouraged to nest where the median distance to the nearest major road in all directions* is less than 20 km (ideally 25 km), or within a block of land encircled by major roads which is less than 200 sq km (ideally 2,000 sq km). However, in deciding where to create good habitat other factors must also be considered, such as the potential benefit to other species. In determining a safe distance, habitat quality and local topography should also be considered. The proximity of other potential barriers to dispersal such as cities, uplands and the sea should also be taken into account.

*see Chapter 10 for a description of measurement method

Reducing the impact of major roads (see also Appendix 2)

The perceived need to reduce Barn Owl road deaths is primarily driven by the species rarity and a desire to reverse its decline. Whilst from a welfare perspective road death tolls should be reduced, from a conservation point of view the numbers killed on major roads might be less important if the species was common. Indeed an increase in Barn Owl road mortality could be an indication that population level was rising. The impact of major road deaths on the Barn Owl population could be greatly reduced by measures to increase the population away from major roads rather than by making any drastic changes to the major roads themselves. Food supply exerts by far the most powerful influence on Barn Owl nesting success and survival. Therefore expansion in the Barn Owl population away from roads must be based primarily on improvements in the quality of potential foraging habitat.

However, in spite of the existing deployment of public funds, the vast majority of farmland is still intensively managed and lacks ideal foraging habitat for Barn Owls. Although Britain's Barn Owl population level may have stabilised (at around 4,000 pairs) there is, as yet, no sign of an overall population recovery. With an uncertain future for the British countryside, every effort must be made to maintain existing populations by preventing further decline in the hope that widespread major improvements in habitat will one day become reality.

Any deterioration in the current situation must be avoided. It is imperative that no new major roads are built in rural areas where major roads are currently absent and Barn Owl populations still present within 25 km. This includes motorways, dual carriageways, modern two/three lane "A" roads and local bypasses.

Roads with continuous 2-3 metre tall hedges next to the metalled surface are acceptably safe for Barn Owls, but roads without such obstructions to low-level flight are not safe. Roads with rough grass verges are more attractive to Barn Owls but those without rough grass verges also cause mortality. The extent to which the presence of rough grass verges makes roads more dangerous to Barn Owls is unknown. Similarly the importance of traffic speed in relation to road design is unknown. However, the presence or absence of continuous low flight obstructions is almost certainly much more important than these other variables. If Barn Owls were unable to fly across roads within vehicle heights they would not be killed, irrespective of how often they visited the roadway, the number of vehicles, traffic speed etc.

Considering major roads, it is suggested that the Barn Owl kill-risk factors in descending order of importance are as follows:

(Estimated importance score given in parentheses)

- Presence/absence of continuous low flight obstructions (10).
- Elevation of the carriageway (sunken, or level/embanked) (4)
- Presence/absence of rough grass verges (3).
- Traffic density (2)
- Traffic speed (2)
- Vehicle size (2)
- Number of traffic lanes (1)

There can be little doubt that the creation of continuous 2-3 metre hedges immediately next to the metalled surface of all major roads in Britain would drastically reduce Barn Owl road mortality, but safety considerations, current landscape policies and the conservation of other wildlife mean that the scope for creation is limited. However, effective low-flight obstacles do exist on a few short sections of major road. On the M5 motorway close to the Devon-Somerset border, a hedge bank was constructed immediately adjacent to the hard shoulder on which shrubs are growing and behind which stand closely spaced trees. This is an excellent example of how low-flight prevention could be achieved. If such features were created on both sides of long sections of major road there can be little doubt that deaths would be effectively minimised. Where verges are particularly wide, areas of rough grass could be maintained behind effective natural screens such as this.

The double-screening of significant lengths of major road is unlikely to be implemented generally but could nevertheless be used where major roads pass through areas of above-average habitat, such as unimproved grassland flood plains, expanses of rough grassland (such as Salisbury Plain), or where groups of farms or estates have entered into agri-environment schemes and created Barn Owl habitat. However, this would leave unprotected the vast majority of major roadway passing through typical farmland, which is where most Barn Owls occur and struggle to survive.

It has been suggested that short lengths of low-flight prevention screening could be used where roads traverse linear habitat features such as drainage ditches, or at Barn Owl mortality "black-spots". The idea has some merit. However, where the end of the screen was visible from the intersection point it is probable that the birds would fly around the screens rather than over them. Therefore the screens would need to extend in either direction, probably for at least 100 metres. In landscapes where linear features meet major roads at short intervals, such as hedges in Devon or ditches on the Somerset levels, the screens would need to be virtually continuous and the idea has limited practical application. An additional difficulty is that Barn Owls are likely to hunt along the rear edge of the screen, effectively a woodland-edge habitat and then cross the carriageway at low level wherever the screen ends.

Reducing the availability of small mammals on road verges has been suggested, but is generally impractical and undesirable for a variety of reasons discussed in Appendix 2. Even where major roads have no verges, or verges without rough grass, Barn Owls are killed. In some areas, dense ground cover such as bramble or gorse has been allowed to spread across the entire width of the verge, which has greatly reduced Barn Owl access to small mammals. In areas where the loss of verge grassland is acceptable, such ground cover would reduce the attractiveness of the verge to Barn Owls and may reduce mortality. Further research is needed in order to determine the effectiveness of such measures. Current indications are that it would be much less effective than the creation of low-flight prevention screens.

M5 *Close to the Devon – Somerset border; an excellent example of how low-flight prevention could be achieved*
Photo: Frances Ramsden *Photo: David Ramsden*

A new hedge bank on the A361 North Devon Link Road effectively screens fast cars
Photo: Stuart Dawber

Human habitation is screened from the M6 – Barn Owl habitat should be screened too
Photo: David Ramsden

General Summary

Main Points from Chapters 1-10 and Appendices 1 & 2

Chapter 1

- Britain's Barn Owl population suffered a substantial decline throughout most of the 20th century.
- The proportion of recorded deaths attributed to road traffic increased from 6% in 1910 -54 and 15% in 1955-69, to 35% in 1963-70 and 50% in 1991-96 (Newton *et al*. 1997).
- The relative importance of road deaths as a cause of population decline is unknown.
- Post fledging survival rate exerts a more powerful influence on overall Barn Owl population level than any other life-cycle parameter (Percival 1990).
- Illner (1992) stated that road deaths accounted for an estimated 10-15% of all adult deaths in the population and may indeed have contributed to the Barn Owl's long-term decline.
- An eighteen-year study in The Netherlands clearly identified an expansion of the main road network and the resulting *"heavy losses"* as a cause of decline (De Bruijn 1994).

Chapter 2

- Three years after the construction and opening of a new 22 km dual carriageway in Devon, all Barn Owl roost sites (within 0.5 km) occupied prior to the road development were no longer occupied. It is highly probable that the new road was the main cause of this decline in the use of roost sites.

Chapter 3

- The number and status of occupied Barn Owl sites within 0.5 km of a 14 km section of motorway was simultaneously compared with two non-motorway control areas. Occupied roosting and breeding sites were found in both control areas but none were found in the motorway area. It is proposed that this was due to the presence of the motorway.

Chapter 4

- In the county of Devon (the research study area) there are approximately 300 pairs of Barn Owls distributed across the road network. Around 700 young fledge each year and for the population level to be maintained approximately 216 have to survive.
- The Barn Owl Trust data used was collected over a 15 year period and consists of 1163 BTO rings fitted, 257 ring recoveries, 1138 sightings of live Barn Owls and details of 162 un-ringed casualties.
- The verges of all Devon's major roads (motorway, dual carriageway and modern A roads) are dominated by rough vegetation that normally includes areas of rough grassland: the primary habitat of Field Voles - the Barn Owl's main prey.
- The verges of Devon's minor roads are bordered by hedgerows: earth banks dominated by scrub, annual flowering plants, ferns and brambles and cut annually to a height of 2-3 metres.

Chapter 5

- There are no significant differences between the Barn Owl population of Devon and that of Britain as a whole.
- It is suggested that investigations based on Barn Owls in Devon are generally applicable to British Barn Owls.

Chapter 6

- Along minor roads Barn Owls are fifty-seven times more likely to be reported as seen-alive than found-dead.
- Along major roads Barn Owls are three times more likely to be reported as found-dead than seen-alive.
- Minor roads are unlikely to have a negative affect on Barn Owl populations.
- When individual Barn Owls encounter a major road they very quickly become casualties (or otherwise disappear).
- Barn Owls do not disperse along major roads.

Chapter 7

- The probability of dispersing young from any given nest site becoming major road casualties cannot be assessed by quantifying the amount of major road within 10 km of the nest.

Chapter 8

- Non-road deaths and minor road deaths are numerous in the early stages of juvenile (post fledging) dispersal and within a relatively short distance of the nest sites.
- Non-road deaths and minor road deaths decrease with both (dispersal) time and distance, but major road deaths increase with time and distance.
- Barn Owls that survive the early stages of dispersal may have learned to avoid frequently encountered hazards (lack of food, water tanks, overhead wires and minor road traffic).
- Barn Owls that reach major roads are those that have survived exposure to other hazards.
- It is concluded that most Barn Owls killed on major roads are not those that would have died anyway. Rather, major roads primarily kill older owls that should have survived.

Chapter 9

- Barn Owls that are killed on major roads do not normally die on the stretch of major road that is nearest to their natal site.
- 72% of Barn Owls which are known to have encountered a major road (n=62) were killed during the encounter.
- Most Barn Owls encountering a major road for the first time quickly become road casualties.
- It is suggested that major roads act as partial barriers to Barn Owl dispersal and may have played a significant part in Barn Owl population decline in parts of Britain.

Chapter 10

- Breeding Barn Owls can only make a net contribution to the maintenance or expansion of the population if their young have a reasonable chance of surviving until breeding age (c.10 months).
- For any site, the probability that young Barn Owls dispersing from that site will encounter a major road can be calculated by quantifying the distance to the nearest major road in 36 directions (10° intervals around a 360° arc) and calculating a median value for the site.
- In Devon, the probability of a juvenile from the most remote nest site encountering a major road is only < 2% while the probability at the most high-risk site is approximately 50%. The median value is approximately 25%.

- It is suggested that encouraging birds to occupy sites with a high major-road-encounter-risk may be a waste of effort because the chances of the adult pair producing any juveniles that survive their post fledging dispersal is very low.

Appendix 1

- Most data on Barn Owl mortality comes from the reported recovery of ringed birds and it is widely acknowledged that such data is biased towards birds that die in conspicuous places such as roads.
- A study in The Netherlands suggested that Dutch ring-recovery data may over represent road mortality by a factor of x 2.3.
- A long-term scientific study in Scotland that sought to avoid road bias nevertheless recorded a high proportion of mortality on roads (22.7 – 56.5%).
- Of all owl and raptor casualties found on major roads, Barn Owls are by far the most frequent victims.
- Barn Owl mortality has two peaks, one in autumn consisting mainly of juveniles and another in late winter consisting of adults and juveniles.
- It has been suggested that Barn Owls are attracted to hunt the verges of major roads by the presence of suitable habitat, such as rough grass supporting small mammal populations. However, Barn Owl deaths do not only occur in areas with suitable verge habitat.
- It has been suggested that deaths are sometimes concentrated where roads traverse other linear habitat features.
- Out of 56 reported sightings by the general public of live Barn Owls seen from a major road, there were more birds reported as flying directly across the road than reported as hunting the verge.
- There is a lack of published data concerning the extent of the use of road verges by owls and raptors.
- It has been suggested that Barn Owls use major road verges as dispersal corridors but no evidence for this was given.
- Roughly half of all Barn Owls found dead on major roads are found lying on the "hard shoulder" or in the "road gutter" which suggests they were struck when starting to cross the carriageway.
- In certain circumstances, bright lights can cause temporary blindness in birds but there is no evidence that this causes birds to be struck by vehicles.
- The chance of any individual road casualty being reported is subject to a wide range of variables.
- Individual Barn Owls are occasionally carried long distances after having been struck by a vehicle before dropping off. This can result in some unusually long distance recoveries.
- Barn Owls are less likely to be killed on sections of major road that are sunken rather than level or embanked.
- The possible influences of traffic speed and traffic density on owl mortality should not be over-simplified.
- There is no evidence that the relative inexperience of young owls is a contributory factor in major road deaths. Perhaps due to lack of previous exposure, individual Barn Owls may have no concept of the danger posed by major roads and therefore no desire to avoid them.

- It has been suggested that road victims are often under-weight or weak individuals which are going to die anyway. However, studies that have quantified the bodily condition of road casualties have shown that this is not the case.

Appendix 2

- Measures to reduce the adverse impacts of major roads on Barn Owls in Britain (mitigation measures) have not been generally adopted by road designers and managers.

- The main guidance documents and good practice guides on reducing the impact of roads on wildlife have failed to recommend mitigation measures for Barn Owls.

- The Government of The Netherlands acknowledged that the Barn Owl is both the most rare and the most susceptible species and led the way on the incorporation of wildlife mitigation into road schemes, but failed to recommend or generally implement appropriate measures for Barn Owls.

- On balance, road verges are an important wildlife resource and current developments in management practice are aimed at increasing their suitability for wildlife.

- It has been suggested that small mammals should be positively encouraged to live in road verges and that hunting perches should be provided for predatory birds such as Kestrels (thus increasing the attractiveness of major roads to Barn Owls).

- The large-scale mowing of rough grass verges, which would need to be frequent in order to discourage small mammals, is considered to be both uneconomic and undesirable in conservation and landscape terms.

- The planting of dense shrubs or woody ground-cover plants in order to reduce access to small mammals by aerial predators may be generally unacceptable.

- New hedgerows or lines of closely-spaced trees to force birds to fly higher whilst crossing roads would need to be positioned close to the carriageway in order to be effective. This has implications for driver visibility and other aspects of road safety.

- It has been suggested that Barn Owls could be positively encouraged to frequent major road areas by the creation of additional corridors of rough grass running parallel to the road verges and the provision of owl nesting boxes. It is hoped that with an increased food supply the birds' survival and nesting success might exceed any additional road mortality. This is based on untested assumptions and of limited application since it would involve radical changes to lands beyond the control of the Highways Agency.

- The Highways Agency is responsible for 10,400 km of major roads, the management of 30,000 hectares of road verge and aims to manage the core network in line with Biodiversity Action Plans.

- The Highways Agency Biodiversity Action Plan (HABAP) 2000 included the management of road verges for small mammals for the benefit of Kestrels.

- The HABAP aimed to reduce Barn Owl mortality whilst ensuring the favourable management of Barn Owl habitat. The extent to which these aims are mutually exclusive was not mentioned.

- The HABAP stated the Highways Agency's aim to "liaise with the Barn Owl Trust regarding their report (this report) and implement appropriate actions".

Chapter One - Introduction

1.1 Barn Owl Decline

Fossil records suggest that the Barn Owl *Tyto alba* has been in existence for roughly two million years (Bunn *et al*. 1982) and early literature suggests it was the most common owl species in Britain in the 18th and early 19th centuries (Holloway 1996).

Evidence of Barn Owl decline in Britain, which probably started in the mid 1800s, is well documented (see for example Toms *et al*. 2000). Between 1932 and 1985 the loss was estimated at 69% (Blaker 1933; Shawyer 1987). However the surveys on which this figure is based were not considered as being "satisf actory quantitative information" (Percival 1992) and were unable to "stand up to critical scrutiny" (Taylor 1994). More recently, the first reliable population estimates were produced following a three -year scientifically based survey: Project Barn Owl. Overall, the estimate for the period 1995-97 was circa 3,500 to 4,000 pairs, with confidence intervals of c. ± 30% (Toms *et al*. 2001).

Using data from Gibbons *et al*. 1993, it can be estimated that in Britain the Barn Owl is now five times less common than the more familiar Tawny Owl *Strix aluco*. Anecdotal evidence suggests that, historically, Barn Owls were resident on most farms, whereas, today, evidence of occupation is generally found on less than one in fifty farms (personal observation).

In recognition of the species decline the Barn Owl is listed in Schedule One of the Wildlife and Countryside Act 1981; Birds of Conservation Concern - Amber List (Gregory *et al.* 2002); and Species of European Conservation Concern (Batten *et al*. 1990; Tucker & Heath 1994).

1.2 Causes of Decline

Numerous authors have listed probable causes of Barn Owl decline and opinions vary as to their relative importance (compare, for example, Shawyer 1987 and Taylor 1994). A small number of detailed studies have attempted to quantify the impact of some of the factors that may have reduced nesting success, increased mortality, or both (for example, Percival 1990 and Taylor 1994 in Britain and De Bruijn 1994 in Europe). There appears to be a strong consensus that a) the causes of decl ine are numerous and b) the reduction in food supply as a result of agricultural intensification is the principal factor.

1.2.1 Reduction in food supply

From the mid 19th and throughout the 20th centuries, increasing agricultural intensity resulted in t he loss of prey-rich habitats. Specific changes include loss of unimproved pasture, increase in stocking rates, the switch from hay-making to silage, loss of rough field margins and hedgerows, the switch from spring sown to autumn sown cereals and changes in grain storage (Chamberlain *et al.* 2000). The loss of unimproved and rough grassland was estimated at 92% (Fuller 1987) and hedgerow loss at 23% (Haines -Young *et al*. 2000). As a result, the amount of Barn Owl prey (mainly voles, shrews, mice and rats) on farmland has been greatly reduced and this is closely associated with reduced nesting success and an increase in Barn Owl mortality (Taylor 1994).

1.2.2 Loss of nest and roost sites

Barn Owls prefer roost and nest sites that afford shelter from the elem ents and dryness is important (Taylor 1994). Evidence suggests that the loss of suitable rural buildings and large dry tree cavities has been a limiting factor in some areas (Petty *et al*. 1994; Taylor 1994). Even in local areas where apparently suitable potential nest/roost sites are abundant, the loss of an occupied site has been shown to have a negative effect on local Barn Owl distribution (Ramsden 1998). The provision of nestboxes has been shown to increase numbers in some areas (Juillard & Beuret 1983; De Bruijn 1994) and approximately 25,500 boxes have been erected for Barn Owls in Britain (Toms *et al*. 2001). However, nestbox sites and positions are generally selected for human satisfaction and not always in accordance with the species' needs (personal observation). The loss of suitable roost and nest sites has caused local Barn Owl declines and a lack of suitable sites may still limit Barn Owl abundance in some areas.

1.2.3 Poisoning

There is evidence to suggest that organochlorine compounds used as agricultural pesticides caused a decline in Barn Owl numbers in parts of eastern England following their introduction in the 1940s and that numbers recovered following their withdrawal in the 1970s (Percival 1990). However, other organochlorine compounds, such as Polychlorinated biphenals (PCBs) have also been detected in Barn Owls (Cooke *et al*. 1982).

PCBs are industrial pollutants that, unlike pesticides, are not deliberately released into the environment but are nevertheless common, widespread and persistent (Cooke *et al*. 1982). Extremely low liver residues (less than 10 parts per million) of these compounds are capable of causing behavioural and hormonal changes in captive birds (Cooke *et al*. 1982). The extent to which the behaviour of wild Barn Owls may be affected is unknown.

The increasing toxicity and use of rodenticides is also a cause for concern. Research has shown that the proportion of Barn Owls that contain one or more of these poisons rose from 5% in 1983-4 to 38% in 1995-6 (Newton *et al*. 1999). Individual Barn Owls are known to have died after eating poisoned rodents (Newton *et al*. 1999) and it is highly probable that such deaths are under-recorded, as reported recoveries are biased towards birds that die in conspicuous places (Illner 1992). The effects of a sub-lethal dose of rodenticide appear to be unknown.

Overall, the extent to which poisoning has caused Barn Owl decline is unknown.

1.2.4 Climate change and weather conditions

Human induced global warming is thought to be changing the world's climate with the result that extreme weather conditions are becoming more frequent (DTI 2003). It has been suggested that extreme drought may cause a reduction in vole numbers and starvation in Barn Owls (Bunn *et al*. 1982). High winds may temporarily prevent Barn Owls from hunting (Glue & Nuttall 1971; Madge & Tyson 1987) and have certainly caused the loss of numerous hollow-tree nest sites in south-east England, such as those lost during the Great Storm of October 1988. Barn Owls are unable to hunt during heavy rainfall (personal observation). However, Percival (1990) showed that although snow, rain and low temperatures were associated with reduced breeding success, they explained only a small proportion of the variance. Overall, it is difficult to quantify the relative importance of the weather as a direct cause of Barn Owl decline. However, it is almost certainly much less important than a decline in prey abundance (Taylor 1994).

1.2.5 Other causes

The range of other suggested causes of Barn Owl decline within the literature include:-

Competition for resources with Tawny Owls (Shawyer 1987; Percival 1991)
Competition for resources with released captive-bred Barn Owls (Percival 1990)
Deliberate persecution (Shawyer 1987)
Urbanisation (Shawyer 1987)
Increased human activity (Shawyer 1987)
Increased road mortality (see 1.3.1).

1.2.6 Summary

Evidence suggests that Britain's Barn Owl population suffered a substantial decline throughout most of the 20th century, primarily as a result of changing farming practices. Whilst the loss of potential roost/nest sites has almost certainly been a major factor in some areas, the relative importance of other factors, such as climate change, poisoning and road deaths, is unknown.

1.3 Barn Owls and Roads

1.3.1 Road mortality as a cause of Barn Owl decline

In Britain the first motorway was built in 1959, since which the total length of motorway and dual carriageway in Britain has risen to over 9,000 km.

Numerous authors have suggested that road mortality is, or could be, a contributory factor in the species decline, including Ratcliffe (1977), Marti & Wagner (1985), Pearce (1986), Ehresman *et al*. (1988), Percival (1991), Illner (1992), De Bruijn (1994), Toms (1996), Shawyer & Dixon (1999), Fajardo (2001).

However, it is very difficult to asses the relative importance of road deaths for a variety of reasons: -

a) Not all dead Barn Owls are found and/or reported.
b) Information based on the finding/reporting by the public of ringed birds is biased towards road casualties (they are more likely to be discovered than birds lying in secluded roosts or open fields).
c) The probability of a road casualty being reported depends upon a wide range of variables that are difficult to assess.

A study based on the post-mortem analysis of carcasses submitted by the public showed that the proportion of recorded deaths attributed to road traffic increased from 6% in 1910-54 and 15% in 1955-69, to 35% in 1963-70 and 50% in 1991-96 (Newton *et al*. 1997). Over the same period the Barn Owl population was estimated to have declined by about 70% (Shawyer 1987).

Illner (1992) set out specifically to determine whether road deaths involving adult Barn Owls were responsible for long-term population declines and examined methodological problems caused by the over-representation of road deaths in owl mortality data. He stated that road deaths accounted for an estimated 10-15% of all adult deaths in the population and may indeed have contributed to the Barn Owl's long-term decline.

Assessing the possible effect/s of roads is difficult because Barn Owl populations are subject to so many different influences. There have been very few highly detailed long-term studies that have simultaneously monitored multiple factors affecting a Barn Owl population. The most noteworthy are those carried out by Iain Taylor (1994) and Onno de Bruijn (1994).

Taylor's study, carried out over a period of fourteen years in southwest Scotland, was by far the most extensive. He clearly demonstrated that prey abundance was the most powerful influence on population size, productivity and mortality. He stated that most road victims were in poor bodily condition and that traffic may not have been their ultimate cause of death. However, the study was carried out in an area of low human population density and very low road density. Perhaps as a consequence of this, Taylor (1994) was unable to assess the significance of road deaths.

De Bruijn's study was carried out over an eighteen year period and compared Barn Owl populations in two adjacent areas in the eastern part of The Netherlands. One of these areas (Liemers) had a higher density of main roads than the other and also contained all of the dual-carriageway/motorway present (c.27 km). De Bruijn demonstrated that Liemers was a *"sink"* area where Barn Owl mortality exceeded productivity and the population declined in spite of the immigration of birds from adjacent areas. An expansion of the main road network and the resulting *"heavy losses"* were clearly identified as a cause of decline (De Bruijn 1994).

1.4 Background to the Major Road Research Project

1. 4. 1 The Barn Owl Trust

The Barn Owl Trust is a registered charity, the primary purpose of which is the conservation of wild Barn Owls. The Trust was founded in 1988, based on the work of a small group of conservation volunteers that started in 1985. Nationally, the Trust's main role is the provision of information in response to enquiries received from the public and conservation professionals. In addition the Trust has proactively provided information to target audiences such as Local Authority Planners and conservation organisations and individual Barn Owl enthusiasts.

However, in the period 1988-2000, most of the Trust's effort was directed towards the conservation of Barn Owls in two counties: Devon and to a lesser extent, Cornwall. Here the main activities were the erection of Barn Owl nestboxes, provision of habitat management advice, the monitoring of occupied sites and BTO ringing.

The Trust has also been engaged in various research projects which included investigations into the effectiveness of the release of captive-bred Barn Owls (Ramsden & Ramsden 1989; Green and Ramsden 2001), the distribution of Barn Owls in Devon (Grant *et al*. 1994) and Cornwall (Grant *et al*. 1995) and the effect of barn conversions on local Barn Owl populations (Ramsden 1995, 1998).

1. 4. 2 Study area and data collection

Devon is the second largest county in England, covers an area of 6,711sq km. and is situated on the south - west peninsula of England, bordered by the sea to the south and north, by Cornwall to the west and the rest of England to the east.

Most of the Trust's fieldwork, including practical conservation measures, habitat advisory work, monitoring and BTO ringing, was carried out across Devon. Thousands of surveys of farms and intensive searches of farm buildings were carried out as part of routine fieldwork. Throughout the study period, all evidence of Barn Owls was systematically recorded including, mortality, live sightings, roosting and nesting. Thus, observer effort was well distributed across the study area, both temporally and geographically. Barn Owls were also well distributed throughout Devon with the exception of urban and upland areas (see Chapter 4).

Devon is bisected by a major road (the M5-A38) which has three other significant major roads connected to it (the A30, A380 and A361). Devon also contains many other roads, particularly "traditional" main roads and country lanes. The total length of road in Devon is greater than in any other county. During the study period (1985-1999) Barn Owl Trust staff travelled extensively by car throughout the county and collected all casualties seen, irrespective of road type. Although most journeys were during the day, the author regularly drove at night in all parts of the county, on all types of road, looking out for Barn Owls both alive and dead.

1. 4. 3 Study period

All of the data used in this study were collected in the period 1985 to 1999 inclusive. However, sampling periods vary according to the different methodologies used in each chapter. Please refer to individual chapters for details.

1.5 Aims of the Project

The aim of this study is to increase knowledge of the effects of roads on Barn Owls. In particular, to investigate and/or determine, as far as possible : -

- The effect of a new dual carriageway on local distribution and status
- The effect of an existing motorway on local distribution and status
- To compare the frequency of live and dead Barn Owl reports for each road type
- To gauge the extent to which Barn Owls encounter roads of various types
- To summarise how different road types may affect Barn Owls that encounter them
- To investigate major road density around nest sites and the chances of the young produced becoming major road casualties
- To investigate the age of birds in relation to their finding circumstances and road type
- To investigate the distance moved by first year birds in relation to their finding circumstances and road type
- To describe the dispersal pattern and the influence of different mortality causes and the relative importance of major roads deaths
- To determine what proportion of recovered birds died on a major road that may have been the first one encountered
- To determine what proportion of recovered birds must have survived a major road crossing and what subsequently happened to such survivors
- To investigate the extent to which major roads might act as barriers to dispersal
- To devise a method for calculating the probability for any specific site that a juvenile Barn Owl dispersing from that site will encounter a major road
- To assess the geographical extent of the danger posed by major roads

Chapter Two - Effect of a New Dual Carriageway on Local Barn Owl Distribution and Status

2.1 Summary

Prior to the construction of a 22 km section of dual carriageway, the Barn Owl Trust undertook a local Barn Owl survey on behalf of the Department of Transport. After the road was opened a repeat survey was instigated by the Trust. Each survey consisted of an intensive search of all potential roost or nest sites in a 22sq km study area (500 metres each side of the route), combined with a questionnaire survey with local residents to record sightings.

The first survey (1991) included an on-foot pre-construction search of the exact route of the A30 dual carriageway from Sourton Cross to Liftondown and a vehicle-based search of the 22 sq km. The second survey (1996) was identical, with the exception of the route walk. By the time the second survey was undertaken the dual carriageway had been open for three years and its rough grass verges were well established.

The aim was to record any changes that occurred in the number, status and distribution of occupied Barn Owl sites and in the number of reported Barn Owl sightings in the study area.

All the Barn Owl roosting sites found to be occupied in 1991, prior to the road development, were no longer occupied in 1996. As there were no obvious changes in the area during the period 1991 - 1996 (other than the road development), it is concluded that the road was highly likely to be the cause of the apparent decline.

2.2 Background

Although road construction is sometimes cited as a contributory factor in Barn Owl decline (see, for example, De Bruijn 1994) there is a lack of research into the direct local effects of the construction and opening of new roads.

In 1988, environmental impact assessments (EIAs) began to be required for certain proposed road developments, but few assessments included systematic field searches for evidence of Barn Owls and less than 10% made any reference to Barn Owls at all (Byron *et al*. 2000). In addition, pre-construction wildlife surveys were normally confined to the planned route and did not include surrounding land. Many EIA reports left much to be desired (Spellerberg 1998). Prior to the construction of the A143 Broome by-pass in East Anglia, a Barn Owl survey was undertaken (Toms 1996) but no repeat survey was carried out in order to determine the effect, if any, of the new road on the local Barn Owl population. The general lack of follow-up monitoring is one of a number of failures of the EIA system (Byron *et al*. 2000).

In 1991 the Barn Owl Trust was contracted by Government to survey the planned route of a 22 km stretch of dual carriageway in order to determine if any Barn Owl sites were amongst the buildings and numerous trees due for removal or disturbance. At the author's suggestion the search area was broadened to a width of 1 km (see map 2.1). This was apparently the first road development in Britain to include a Barn Owl survey. During an interview at the construction launch ceremony on 6th November 1991, government minister Christopher Chope MP claimed that the new dual carriageway would be an environmentally friendly road and cited the consideration given to wildlife within the scheme (personal observation).

At its own instigation, the Barn Owl Trust repeated the survey three years after the road was opened to determine the effect, if any, on the local Barn Owl population.

6th November 1991, government minister Christopher Chope MP at the A30 construction ceremony claims the development will be environmentally friendly - Photo: David Ramsden

2.3 Methodology

The author carried out the initial survey in 1991. The entire 22 km route was intensively searched on foot and any occupied or potential Barn Owl sites likely to be lost in the construction process were noted and checked. Owners or tenants of all potential Barn Owl sites within half a kilometre each side of the route were contacted, followed up by site visits. They were asked about present and past Barn Owl activity in the study area and all reports were logged. Having established permission, an intensive search for evidence of roosting and/or breeding was made at all of the potential Barn Owl sites. The survey was carried out in May, prior to the annual fledging period and therefore any evidence found of Barn Owl occupation was assumed to be of established adults, rather than of dispersing or recently arrived juveniles.

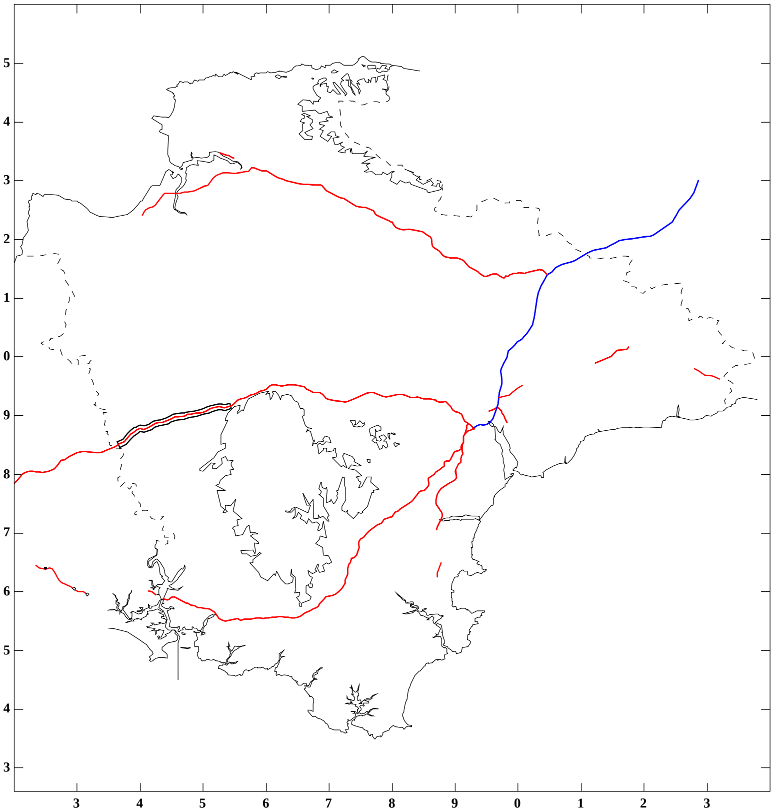
Some locations further than half a kilometre from the route were also intensively searched, either on recommendations from local residents or because they were thought to be suitable locations for nestboxes. The owners of these sites were also asked about past and present Barn Owl activity in the area.

Immediately after completion of the first survey, ten nestboxes were erected, (nine at locations more than 1 km from the planned road and one at three quarters of a kilometre away) in the hope that these might help to mitigate any negative effects of the loss of potential sites along the route.

The survey was repeated in 1996, three years after the new dual carriageway had opened. This study followed the same methodology with the following exceptions:-

a) The route of the road was not walked!
b) The ten nestboxes, having been available for five years, were included in the study.

The results of the two surveys were compared and any differences in the frequency of reported sightings and confirmed occupied Barn Owl sites were noted.



Map 2.1 *The location of the A30 study area in the county of Devon (left of centre).*

2.4 Results

Within the study area, sixty-two locations were checked, of which ten were deemed to be unsuitable for Barn Owls, being either roofless buildings or buildings with no Barn Owl access. None of the buildings or trees due for removal held any evidence of occupation by Barn Owls.

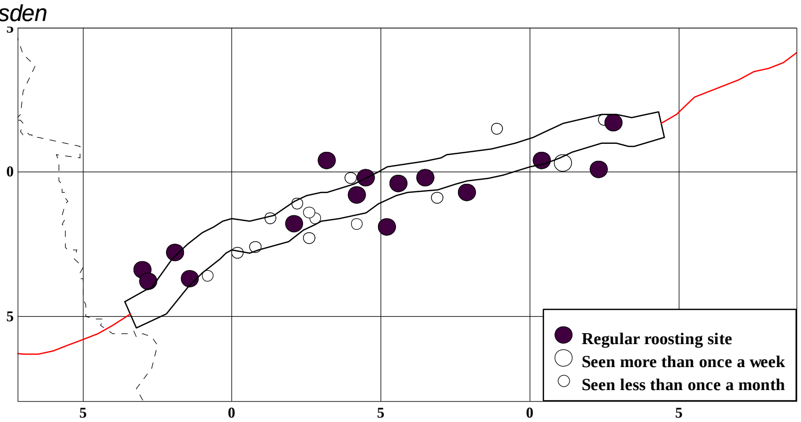
Twenty-nine unconfirmed sightings or reports of Barn Owl occupation were received. Of these, fifteen were within half a kilometre of the proposed route and a further twelve were within one and a half kilometres (see map 2.2). However, only six out of the twenty-nine were recent, that is within the previous six months. (See map 2.4).

Within the study area, two regular roosting sites, both occupied, were discovered situated only 150m and 300m respectively from the planned route. One site contained over 40 pellets plus feathers indicating the presence of a female Barn Owl. The other roost contained 16 pellets. Outside the intensive search area another two occupied regular roosting sites were confirmed (at distances of 1 km and 1.3 km from the route) and selected as nestbox locations.

Before

…and after

Photos: David Ramsden



Map 2.2 *The distribution of all Barn Owl roost sites occupied and reported sightings that occurred, in the period 1980-1993 within the intensive search area (plus outlying reports - see text).*

The ten nestboxes were erected in May 1991. Road construction started in September that year and the new dual carriageway was opened to traffic in March 1993. The road was of normal design, having two traffic lanes in each direction and wide verges on both sides plus a central reservation. The vast majority of verge was not mown and within approximately two years the verge habitat had developed into rough grassland, ideal for small mammals.

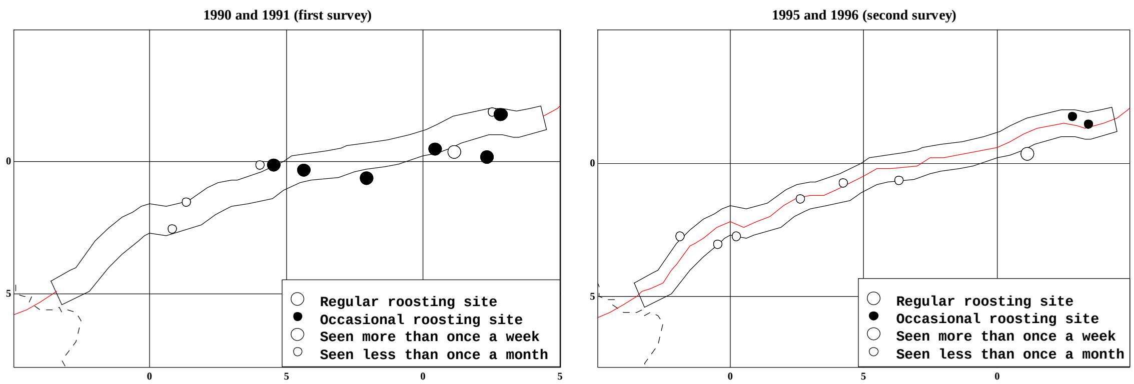
The second survey, in June 1996, successfully re-checked all of the sites and interviewed all the informants who gave evidence in 1991. However, no evidence of current Barn Owl occupation was found (see map 2.4). The evidence suggested that the two regular roost sites closest to the road were occupied until approximately 1994. Nine unconfirmed sightings or reports of Barn Owl occupation were received, some of which dated back as far as 1992. Of these, seven were within half a kilometre of the dual carriageway and three were within one and a half kilometres. However, only five out of the ten sightings were current (within the previous six months). Table 2.1 summarises the findings of both surveys.

Table 2.1 *- The evidence collected at 52 search/interview locations in a 22 sq. km study area in Devon, before and 3 years after, the construction of a new dual carriageway.*

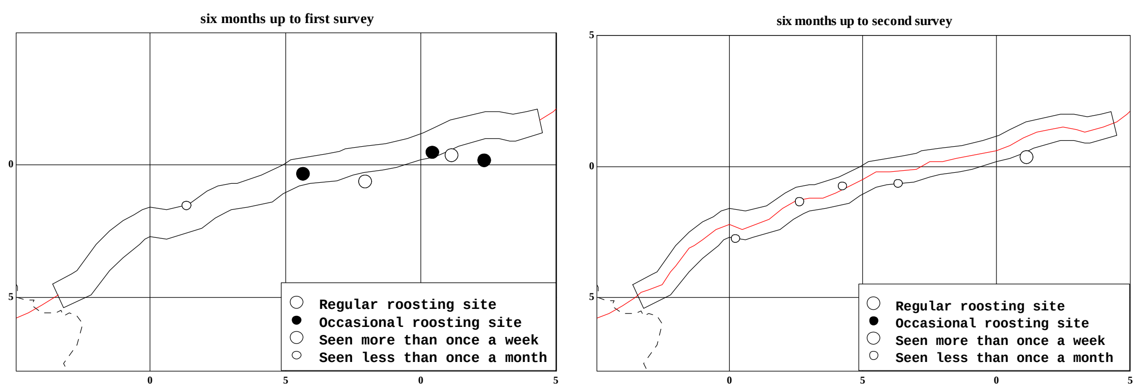
	before	*after*
Currently occupied regular roost sites	*2*	*0*
Currently occupied regular roost sites including outliers	*4*	*0*
Sightings reported (all years)	*29*	*9*
Sightings reported (in previous 6 months)	*6*	*5*

Map 2.3 shows the sightings recorded and roosting confirmed for the two-year periods leading up to each survey. Two occasional roost sites are shown which were occupied after the road was opened and the rough grass verges were established. However, both sites contained minimal evidence. One had only one pellet and the other only three, both dating from late summer/early autumn 1995.

The ten nestboxes were erected in the hope that their presence may encourage breeding at a relatively safe distance from the road. However, in the period between the two surveys, only one of the nestboxes was used, for roosting only and was not used after about 1994. By 1996 two of the boxes were no longer in place owing to a demolition and a redevelopment.



Map 2.3 *The distribution of all occupied Barn Owl roost sites and reported sightings, within the intensive search area (plus outlying reports) in two 2-year periods, leading up to the first survey in 1991 and to the second survey in 1996, three years after the opening o f a new dual carriageway.*



Map 2.4 *The distribution of all occupied Barn Owl roost sites and reported sightings, within the intensive search area (plus outlying reports) in two 6-month periods, leading up to the first survey in 1991 and to the second survey in 1996, three years after the opening of a new dual carriageway.*

2.5 Discussion

The 1991 survey collected numerous anecdotal reports from local people, which suggested that the Barn Owl population in the area had already declined noticeably. Ma ny of the historic sites reported as having been used for breeding or roosting were unoccupied, but the reasons for the apparent decline were unclear. The habitat, a mixture of copses, hedgerows and relatively small fields, although not ideal, seemed adequate. It was disappointing to find only two occupied regular roost sites in the 22 sq. km but this served to reinforce the view that the Barn Owl was indeed a rare bird. The Devon Barn Owl Survey, carried out throughout the county two years later, supported this and gave an estimated mean density of one known occupied site, either roosting or breeding, per 5 km square (25 sq. km). (Grant *et al*. 1994).

A comparison of the results of the two surveys clearly shows that the two previously well used roosting si tes within the search area and the two outliers, became unoccupied. Established adult Barn Owls are highly sedentary (Taylor 1994). It is probable, therefore, that the sites ceased to be used because the birds had died, not because they had moved. Indeed, two dead Barn Owls were reported * on this road in 1995 (the year before the second survey) in spite of the fact that no searches were made for corpses. In the period between the two surveys there were no obvious changes in the farmland landscape, other th an the road development, that may have caused population changes. It should be noted that Barn Owl populations can show year to year fluctuations in response to cyclic changes in food supply (Taylor 1994) and weather (Percival 1990). However, the influence of these factors is less marked in lowland and where Field Vole habitat is fragmented (Taylor 1994), such as the A30 study area. In addition, these factors should not have affected the results because both surveys collected evidence covering several years .

It is considered unlikely that the birds abandoned the area as a result of disturbance during the road development phase as no roost sites were directly affected. Even at roost sites, Barn Owls are surprisingly tolerant of construction activities providing they can remain out of sight (Ramsden & Ramsden 1995).

A comparison with other published results was not possible because, as far as is known, this was the first study of its type. Shawyer (1987) suggested that where new motorways are opened, local Barn Owl populations are depleted, but provided no evidence to support this view. These results provide the first such evidence.

It is clear that prior to the opening of the new A30 dual carriageway, the area held a small resident Barn Owl population. Despite an intensive search, the only material evidence of Barn Owls found three years after the road had opened consisted of four pellets. By chance, two dead road casualties were recorded in the year before the second survey. In the three years following the second survey, four more Barn Owl casualties were recorded on this "environmentally friendly road".

The very low number of occupied sites severely restricts the confidence with which apparent population change can be attributed to any cause. The A30 study should therefore be viewed simply as circumstantial evidence of the effect of major road construction on a local Barn Owl population. As a method of gauging an effect it deserves consideration. However, the species rarity and time consuming nature of intensive searches may mean that a more satisfactory sample size is unattainable using this method, unless considerable resources are deployed. In addition, the simultaneous monitoring of a similar sized area in the locality not affected by the road would have been an advantage.

* by Bob Jones, a Conservation Officer of the Devon Birdwatching and Preservation Society

Chapter 3 - Effect of an Existing Motorway on Local Barn Owl Distribution and Status

3.1 Summary

This study investigated the impact of a long-established motorway on the number and status of occupied Barn Owl sites, by simultaneously comparing the Barn Owl distribution in motorway and non-motorway search areas.

During one summer, three areas, each one measuring 1 km x 14 km, were intensively searched, one along a stretch of the M5 motorway (0.5 km either side of the road) and two control areas without motorways or similar major roads.

Occupied roosting and breeding sites were found in both control areas but none were found in the motorway area. Other factors likely to affect local Barn Owl populations were taken into account and as no other explanation was found, it is suggested that the absence of Barn Owls in the motorway search area was due to the presence of the motorway, causing increased road mortality.

This methodology proved to be an effective, but resource demanding way of assessing the impact of a motorway on local Barn Owl distribution and status. However, owing to the species rarity, a larger study would be required to obtain more conclusive results.

3.2 Background

The possible long-term effect of the presence of a major road on local Barn Owl distribution and status has not previously been investigated. The results in Chapter 2 suggest that in the three years following the opening of a new major road, a localised extinction of Barn Owls can occur. However, it does not necessarily follow that major road areas remain unpopulated after any initial decline. In theory, there are ways in which major road areas could continue to be populated by Barn Owls. Individuals moving in from elsewhere may replace Barn Owls in major road areas that become road casualties. Thus, even if major roads areas are population sinks, they may be continually occupied providing there is a sufficient source population nearby (see 1.3.1). Alternatively, perhaps individual Barn Owls can learn to avoid dangerous roads (see A1.15). Perhaps experienced adults can survive with a major road in their home range.

To date, no attempts have been made to monitor the movements or map the foraging ranges of adult Barn Owls nesting close to a major road (see A1.6). There is also a shortage of data on birds ringed as adults at sites very close to modern roads, possibly because ringers are unlikely to find live birds in these situations. The trapping and re-trapping of ringed birds found nesting or roosting close to a major road is another possible approach that appears not to have been tried, probably for a variety of reasons: finding live birds close to major roads is difficult, trapping is often impractical and most live birds are unringed.

Using coordinates of almost 3,000 reported nest sites across England and Wales, Shawyer & Dixon (1999) stated that less than 1% of sites were within 1 km of a trunk road and that this figure was approximately five times lower than would be predicted by chance. During a study along a 50 km stretch of the A303, they surveyed a corridor 5 km wide (2.5 km either side of the road). Although unable to establish an exact number of nests, they considered that the breeding population in any one year was unlikely to exceed 5-8 pairs. However, it was estimated that the area (2.5 ten km. squares) would have supported at least 25 pairs if the road were not present. The basis of the latter estimate is unclear, as it is far in excess of the national average figure of 2-3 pairs per occupied 10 km square that was also given (Shawyer & Dixon 1999).

This study aimed to measure the effect of the presence of a major road on a local Barn Owl population by quantifying the distribution and status of occupied sites and comparing a motorway area with control areas which were far enough away to ensure that any birds occupying sites in the control areas were unaffected by the motorway. There appear to be no other studies based on systematic intensive-searches of road and non-road areas.

3.3 Methodology

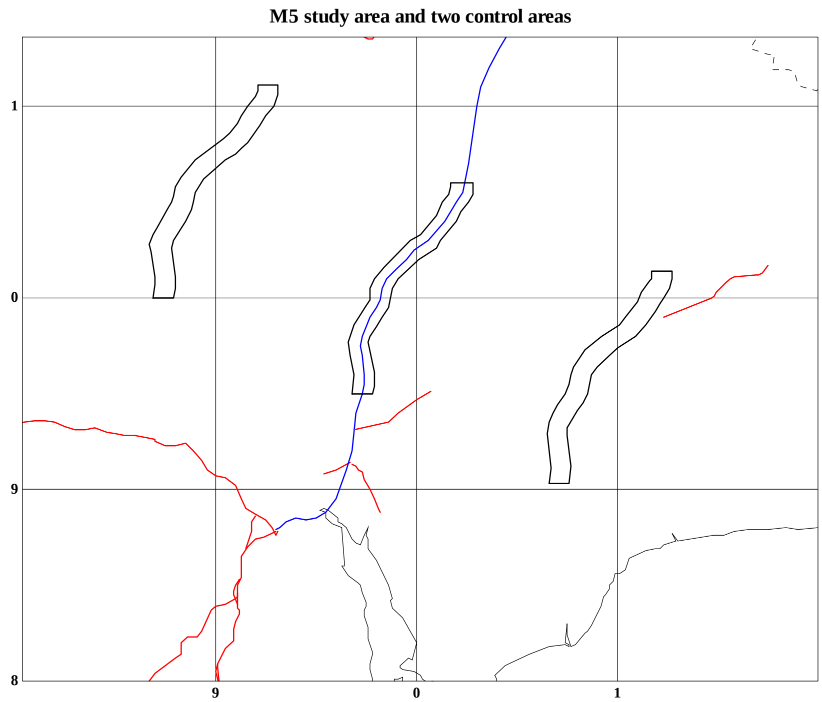
A section of the M5 in Devon that was constructed in 1975, 21 years before the search, was selected as the motorway search area, the length of which (14 km) was determined by the extent of the rural area between Exeter and Cullompton and also by resource limitations. A search area width of 1 km was determined by the species minimum foraging range in the breeding season so as to ensure that any occupied sites contained birds that were certainly exposed to the motorway. Increasing the width of the motorway search area would have increased the risk of including sites containing birds whose foraging area did not include or border the motorway.

The motorway study area dictated the size and shape of the two control areas that were situated 10 km to the west and 10 km to the east. This distance was determined by the normal maximum winter foraging range, so as to ensure that independent populations were studied (see m ap 3.1).
Barn Owl abundance can be subject to a wide range of influences. It is well known, for example, that Barn Owl numbers, population density, survival and productivity are closely linked to habitat quality and site availability (Taylor 1994). In addition, localised extinctions can occur in areas where birds have been displaced by the conversion of old agricultural buildings (Ramsden 1995, 1998). Particularly where site availability is a limiting factor, the provision of nestboxes can increase abunda nce (Juillard & Beuret 1983; Taylor 1994). All these factors were therefore taken into account. By searching all areas within one summer, the possible effect of temporal changes in prey abundance was avoided.

During July-September 1996, all potential roost or nest sites in buildings and trees were intensively searched for signs of occupation in the form of pellets, feathers, nests etc. The age of Barn Owl pellets was estimated using the method described by Ramsden & Ramsden (1995). As well as Barn Owl status, additional factors were recorded for each potential site such as the availability of potential roosting and nesting places, the suitability of access, the existence of a nestbox and altitude. English Nature phase one habitat survey data, updated by field observations, provided an assessment of habitat suitability.

The number and status of occupied sites, habitat quality, number of barn conversions and the mean altitude of potential sites were calculated for each study area. Barn Owl status, the suitability of potential foraging habitat and potential roost and nest sites, were quantified using the methods described by Ramsden (1995). The mean values of the control areas were then compared with the values found in the motorway area.

The M5 between Exeter and Cullompton
Photo: David Ramsden



Map 3.1 *The geographical location of the M5 study area, to the north of Exeter and the two control areas in the county of Devon.*

3.4 Results

The mean altitude of potential sites was 41 metres above sea level in the motorway area compared with 153 metres in the control areas. However, both areas were within the species' normal altitude range in Britain.

Chi-square analysis indicated that there was a significant association between the availability of potential sites and study area type, whether motorway or control (Total $X^2 = 9.324$; DF = 3: $P < 0.05$). However, all three areas afforded numerous unoccupied sites with potential roosting and breeding places (see figure 3.1).

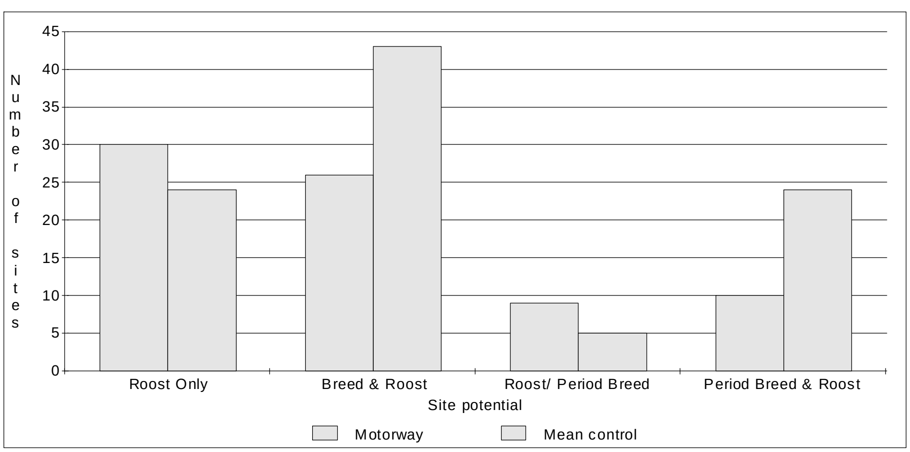
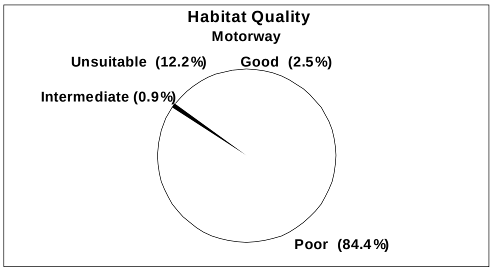


Figure 3.1 *- The number of potential Barn Owl roost and nest sites in the motorway and control areas. "Period" refers to sites that were only available periodically through the year.*

Only one Barn Owl nestbox was available in the motorway area, whereas the mean number for the control areas was 7. There was only one barn conversion in the motorway area, but a mean of 5 in the control areas.

Both the motorway and the control areas were dominated by poor Barn Owl habitat, mainly intensively managed grassland and annually cultivated f ields. The only good Barn Owl habitat (rough grassland) was found in a motorway area (see fig. 3.2). The length of all linear habitat features in the motorway study area was broadly similar to the mean length of all linear habitat found in the control area s (see table 3.1).



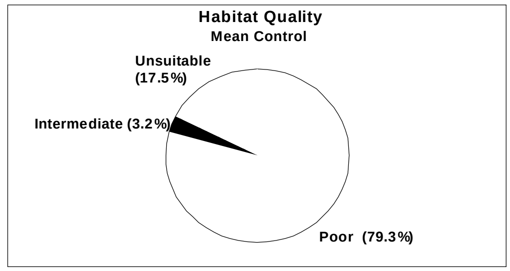


Figure 3.2 *- A comparison of the habitat quality between search areas* .

Linear habitat type	Motorway	Mean Control
hedgerows	35	50
edge of drainage ditch, stream & rivers	21	10
woodland edge	6	6
total lengths	62	66

Table 3.1 *- The length (km) of linear habitat features in the search areas , excluding the 28 km of motorway verge.*

Only 2 sites in the motorway study area contained any evidence of Barn Owl occupation and both we re only visited occasionally. However, the control areas contained an average of 5.5 occupied sites, comprising 1.5 breeding sites, 3 roosting sites and 1 site that was only visited occasionally (see fig. 3.3. and table 3.2).

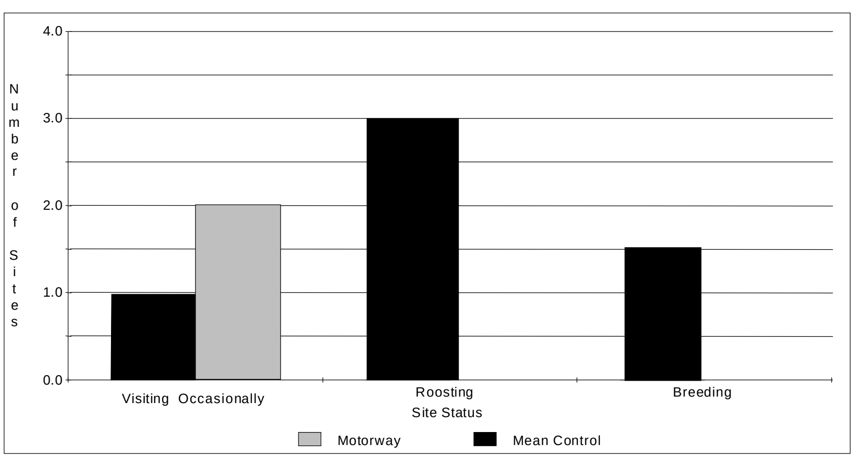


Figure 3.3 *- A comparison of Barn Owl site occupancy and status between study areas* .

MOTORWAY AREA			
site number	Barn Owl status	evidence	age range
M1	visiting occ.	2 pellets	21-30 months
M2	visiting occ.	1 pellet	8 months
CONTROL AREA A			
A1	breeding	nest debris + 30 pellets	6-30 months
A2	roosting	30-40 pellets	6-30 months
A3	roosting	13 pellets	30 months
A4	visiting occ.	2 pellets	1 month
A5	visiting occ.	4 pellets	15-20 months
A6	roosting	15 pellets	20-30 months
CONTROL AREA B			
B1	breeding	nest debris	30 months
B2	roosting	12 pellets	1 week - 1 month
B3	breeding	>80 pellets	fresh - 1 year
B4	roosting	>30 pellets	fresh - 1 year
B5	roosting	40-50 pellets	fresh - 1 year

Table 3.2 *The evidence of Barn Owl occupation found at each occupied site in three 14 sq km areas*

3.5 Discussion

3.5.1 The probable effect of study area characteristics

a) Altitude
Situated in the Culm valley, the motorway study area altitude was only 41 metres above sea level, whereas the control areas straddled numerous hills and small valleys and averaged 153 metres. Bunn *et al*. (1982) showed that 54.3% of British Barn Owl nests were found below 61 metres, but only 15.4% were between 122-183 metres. Weather conditions, habitat quality and survival generally deteriorate with altitude. Thus, in terms of altitude, Barn Owls were likely to be more abundant in the motorway area.

b) Site availability
Despite the higher number of potential sites in the control areas, all three areas contained a more than adequate number of potential Barn Owl roosting and breeding sites. Therefore relative abundance was not likely to be influenced by site availability.

c) Nestbox availability
The reported levels of road mortality may have deterred conservationists from erecting nestboxes near major roads. However, since all the search areas contained an adequate supply of unoccupied potential roosting and breeding sites it is unlikely that the disparate number of nestboxes was a significant factor.

d) Barn conversions
Conversions were more numerous in the control areas. If any of the conversions had caused localised Barn Owl decline, this negative influence was more likely to have occurred in the control areas than in the motorway area.

e) Habitat quality
Habitat was better in the motorway area as it contained the only areas of rough grassland, the optimum foraging habitat for Barn Owls. Thus, in terms of habitat, Barn Owls were likely to be more abundant in the motorway area.

Considering all factors other than the presence of the motorway, the motorway area was more suitable for Barn Owls than the control areas.

3.5.2 Site occupancy and status

The intensive search method used did not differ between search areas. The evidence of Barn Owls found in the motorway area consisted of only three old pellets, whereas the same size control area contained, on average, 1.5 nests and four other occupied sites containing over 125 pellets.

If the motorway was not affecting the birds there should theoretically have been more occupied sites in the motorway area than in the control areas. As this was not the case, it is suggested that the absence of occupied sites in the motorway area was due to the presence of the M5 motorway.

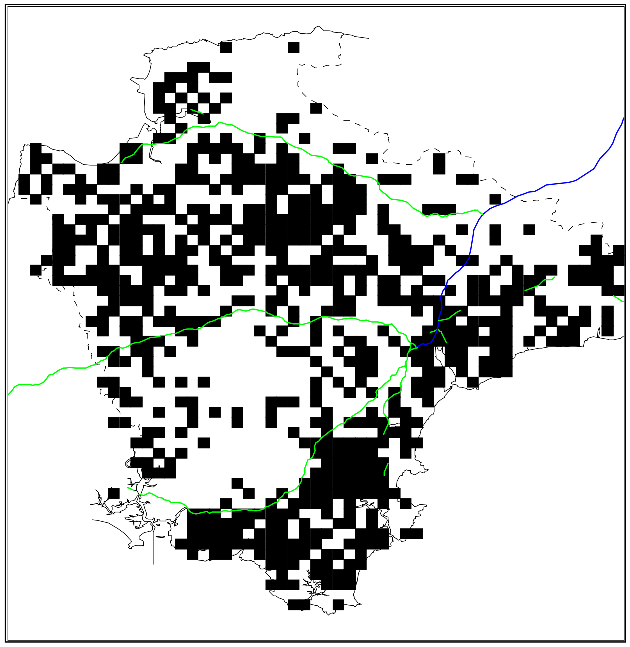
Owing to resource limitations and species rarity, the sample sizes were limited and it was not possible to carry out statistical analysis. However, it appeared that no breeding or regular roosting had occurred in the motorway area for a number of years. This is consistent with the findings in Chapter 2 and the views of Shawyer (1987). Any Barn Owls which started to frequent the motorway study area became road casualties, or disappeared for other reasons, before evidence of their occupation could accumulate. Given that Barn Owls normally produce one or two pellets most nights, the evidence suggests that the bird/s that produced the three pellets found at two sites in the motorway area disappeared very quickly. It is suggested that the birds in question died on the motorway. Indeed, seven dead Barn Owls were reported* on this section of the M5 between 1985 and the search in 1996. No searches were made for Barn Owl casualties and it is highly likely that there were additional road casualties that went unrecorded.

***** One was unringed and six were BTO ringed, of which two were found by the author

Chapter 4 – Background Information: Barn Owls in Devon, Barn Owl Data Used in Chapters 5-10 and Devon's Roads

4.1 Brief Description of Devon's Barn Owl Population

4.1.1 Barn Owl distribution in Devon



Map 4.1 *Distribution of tetrads in Devon that contained one or more known Barn Owl nest and/or roost sites occupied at some time in the period 1985-1999. Source: Barn Owl Trust database.*

Records suggest that Barn Owls are well distributed across Devon with the exception of the upland are as of Dartmoor and Exmoor. In 1993 all known roost and nest sites were checked during the Devon Barn Owl Survey, in which 137 nests and 151 occupied roosts were recorded and the population estimated at 250 to 350 pairs (Grant *et al.* 1994).

4.1.2 Barn Owl population dynamics in Devon

Adult Barn Owl survival in the southwest region averages 64% (Percival 1990), which means that roughly one in three adults dies each year. For a population of 300 pairs to be maintained, roughly 216 juveniles have to be recruited into the adult population each year. The average fledging success rate per nesting attempt is 2.4 (Percival 1990) and most pairs only nest once in most years (personal observation). If 290 out of the 300 pairs nested, the number of young that fledged would be roughly 696. The first year survival rate is 29% (Percival 1990), so the number of juveniles surviving to one year old and being recruited into the adult population (202) is similar to the number of adults that die during the previous year.

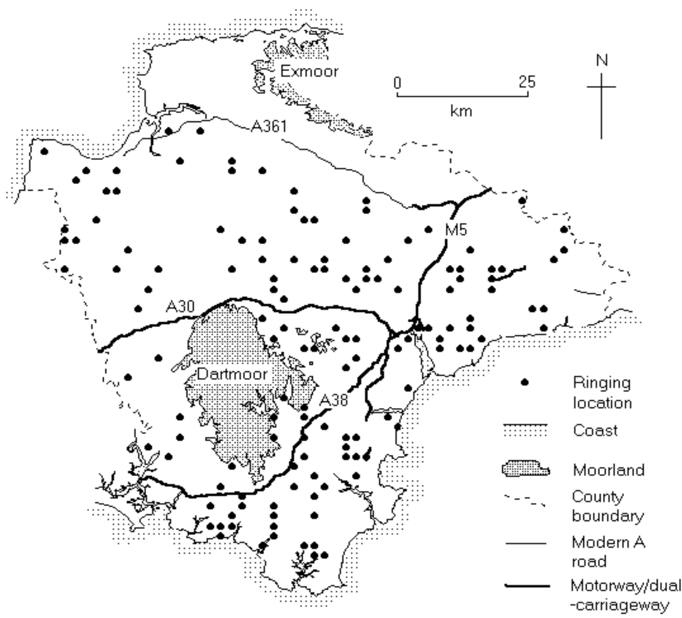
The above summary is based on estimates, using the best information available. Factors such as the net import or export of birds across the county borders and annual variations in survival and productivity have been ignored. In spite of its limitations, this d escription of Barn Owl population dynamics serves to remind the reader that population "turnover" is a fact of life. Populations can only be maintained by an annual supply of new recruits. Percival (1990) showed that first-year survival rate exerted a more powerful influence on overall Barn Owl population level than any other life cycle parameter.

4.2 Barn Owl Data Used in Chapters 5-10

The Barn Owl Trust has collected detailed information on Devon Barn Owls since 1985. This includes data on 154 ringing locations, of which there were 127 where the exact numbers of Barn Owls ringed was known. 1163 Barn Owls were fitted with a British Trust for Ornithology (BTO) ring and 257 ring-recoveries were reported. Most birds were ringed before fledging (pullus), accounting for 214 of the ring-recoveries. Barn Owl ringing was carried out mainly by the Barn Owl Trust, but a few independent BTO ringers were also active in the county. The ringing data included all birds ringed by J Tallowin. No other ringers provided ringing data direct to the Trust, though some extra data were gathered via ring recoveries reported to the BTO or via the Barn Owl Trust.

The Barn Owl Trust also collected other Devon Barn Owl data over the same period. This included 1,515 records of nesting, 1,318 of roosting, 1138 sightings of live Barn Owls and details of 164 un-ringed Barn Owls found dead or injured, of which 102 were road casualties. The reader should note that the records of nesting and roosting include multiple observations at individual sites. The actual number of recorded sites where Barn Owl/s have nested or roosted at some time was circa 1,000.

4.2.1 Geographical distribution of data

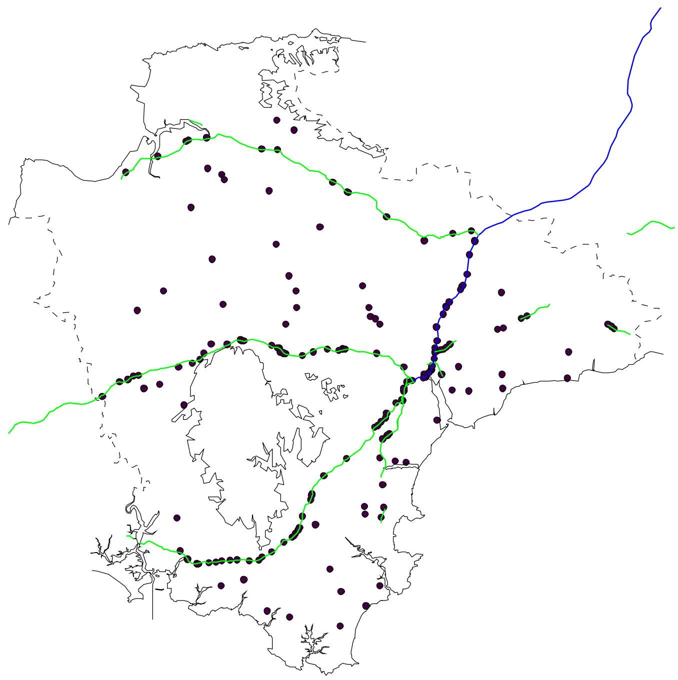


Map 4.2 *The county of Devon, showing major roads and Barn Owl ringing sites*

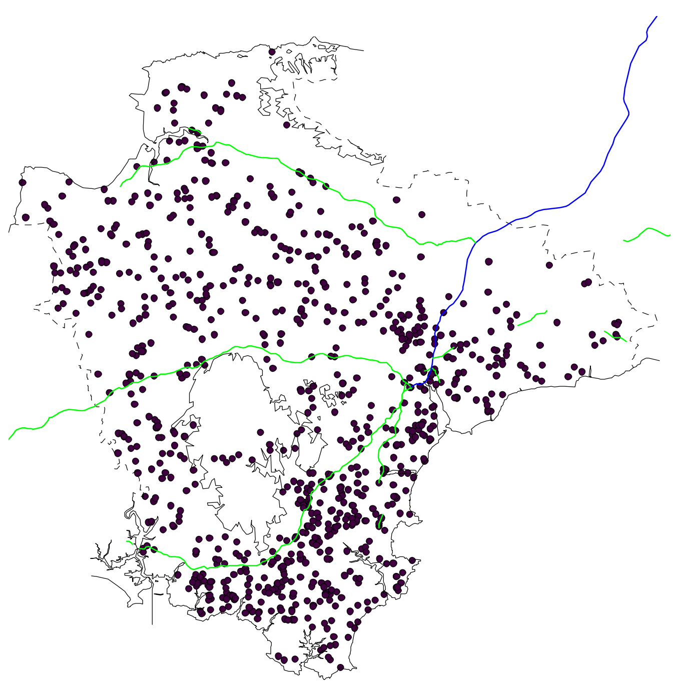
Ringing sites were well distributed around Devon with the exception of the Somerset border area. There were no ringing sites on Dartmoor or Exmoor as is expected for a mainly lowland species.

Both major and minor road casualties were distributed across Devon's road network. Major road casualties were associated with every major road and were not overly concentrated along any particular stretch.

The Barn Owl Trust recorded numerous sightings of live Barn Owls, reported by members of the public. These were mainly birds seen in flight by road users (see Chapter 6). Again, there appeared to be a fair distribution throughout Devon, except for a slightly higher concentration in the southwest and slightly lower in the northeast. It is unlikely that this distribution would have led to any strong bias in the analyses.



Map 4.3 *The county of Devon, showing major roads and Barn Owl road casualties (all road types) used in the analyses.*



Map 4.4 *The county of Devon, showing major roads and reported live -sightings of Barn Owls used in the analyses.*

4.2.2 Temporal distribution of data

Most of these ringing sites were not occupied in every one of the fifteen years and of those that were, nesting did not necessarily take place in every year. Thus, the number of sites a nd the number of young ringed at each site varied typically from year to year. Barn Owl populations and nesting success are well known to show marked year-to-year fluctuations (Taylor 1994).

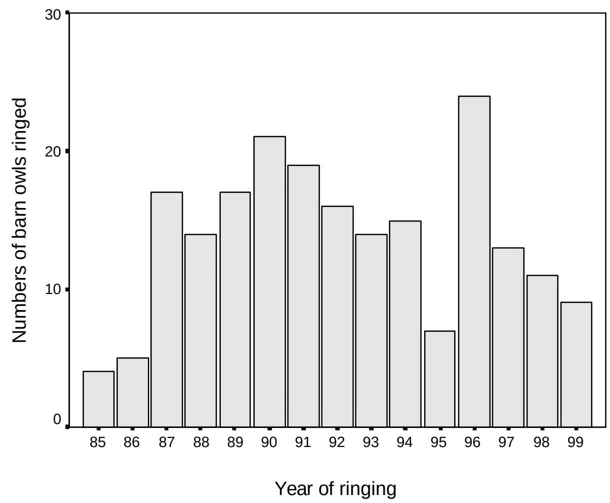


Figure 4.1 *Temporal distribution of Barn Owl ringing througho ut the study period. Those that were captive bred released adults and those that were only recovered as controls were excluded from the data.*

The relatively low number of birds ringed in 1985 -86 was due to the fact that the Barn Owl Trust's own BTO ringing activity was not fully developed in the early years. The low number in 1995 and the high number in 1996 appeared to be due to genuine changes in Barn Owl abundance and productivity reported across England in those years (Toms *et al.* 2000).

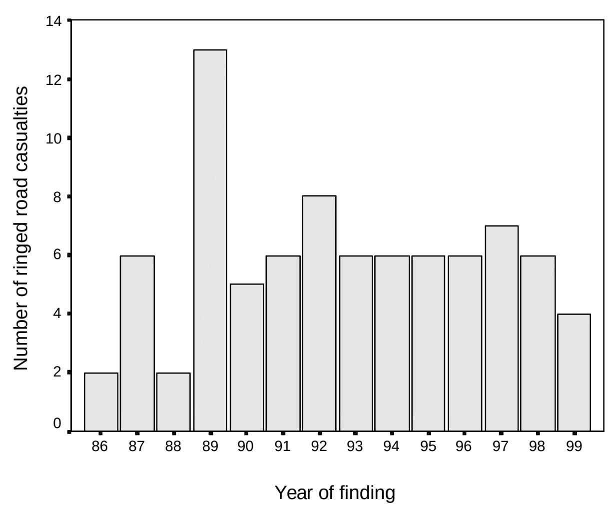


Figure 4.2 *Temporal distribution of Barn Owl road casualty ring-recoveries reported throughout the study period. Those that were captive bred released adults and those that were not recovered in Devon were excluded from the data. None were reported in 1985.*

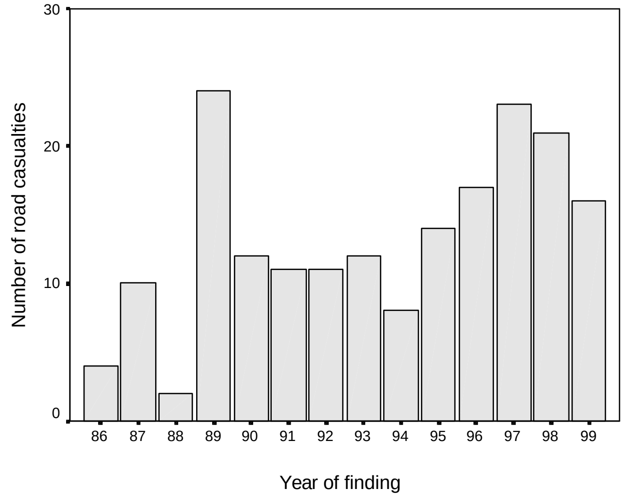


Figure 4.3 *Temporal distribution of Barn Owl road casualties reported throughout the study period (ringed and un-ringed combined). Those that were captive bred released adults and those that were not recovered in Devon were excluded from the data. None were r eported in 1985.*

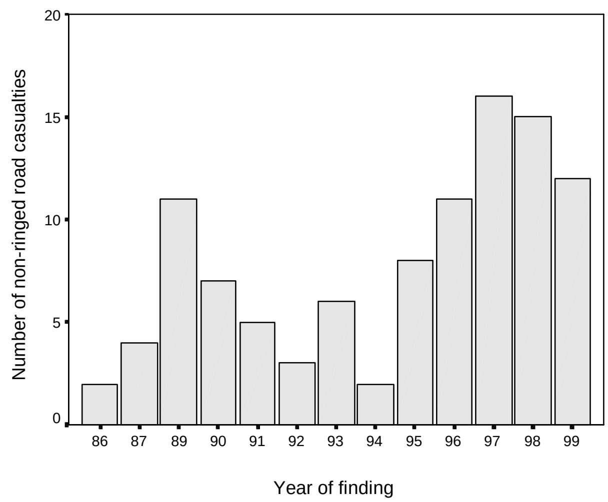


Figure 4.4 *Temporal distribution of un-ringed Barn Owl road casualties reported in Devon throughout the study period. None were reported in 1985 or 1988.*

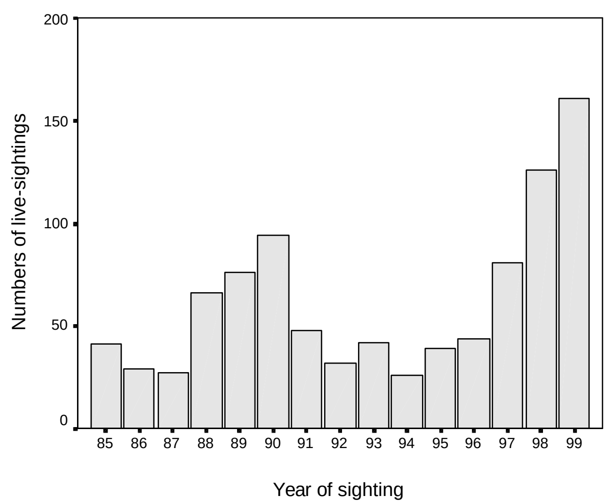


Figure 4.5 *Temporal distribution of reported live-sightings of Barn Owls in Devon throughout the study period.*

The temporal distributions of all data sets were subject to changes in observer effort and reporting rate that were impossible to quantify. Reports to the Barn Owl Trust could only have been made by observers who were aware of the Trust's existence and recording activity. This awareness was subject to temporal change resulting from the Trust's growth and the irregular nature of publicity. No attempt was made to extract these effects from possible yearly variation in population density, productivity and mortality. The scale of temporal fluctuations in the data indicated the importance of the extended data collection period of 15 years, which was used in this study.

4.2.2 Temporal distribution of ringing date and age at ringing

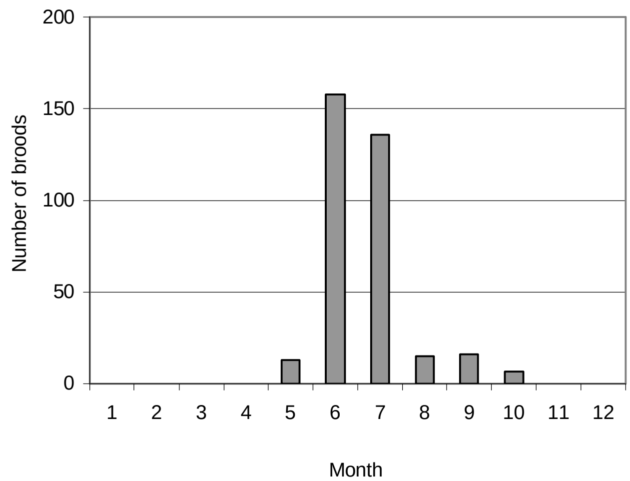


Figure 4.6 *Month of ringing of all Barn Owl broods BTO-ringed by the Barn Owl Trust in the period 1985-1999 in the county of Devon.*

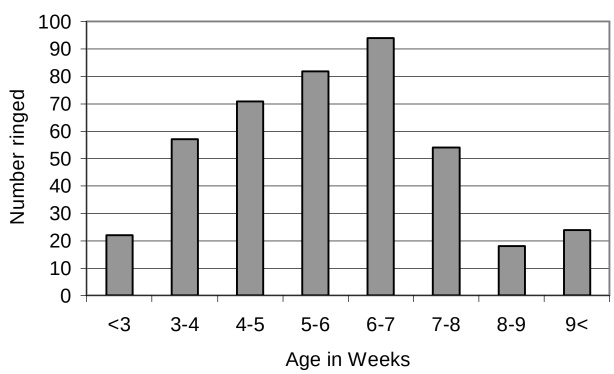


Figure 4.7 *Age at ringing of all Barn Owl pulli BTO ringed by the Barn Owl Trust in the period 1985-1999 in the county of Devon.*

59% of all pulli ringed by the Barn Owl Trust were 4-7 weeks old and 87% were ringed in June-July.

4.3 Description of Devon's Roads

Devon has 14,750 km of roads in an area of 6,711 square kilometres and the majority of all roads are country lanes connecting villages and farms. With the exception of the two upland areas of Dartmoor and Exmoor, where Barn Owls rarely occur, almost every square kilometre contains one or more country lanes. The second most common roads are traditional A and B roads that connect larger villages and towns. Together, these roads are classed as "minor roads" and represent 98.3% of total road length in the county. With the exception of urban roads, the remaining 1.7% of Devon's roads are classed as "major roads" (motorways, dual carriageways and modern A roads), connect larger towns and cities and carry traffic passing through Devon.

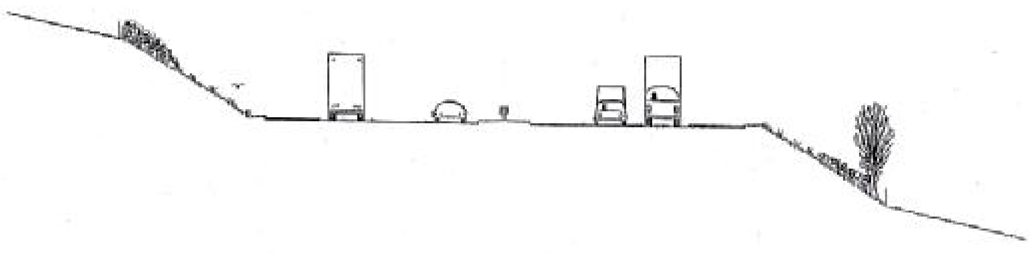


Figure 4.8 *Typical cross-section of a Motorway (M5).*
Typical width excluding verges = 33m. Total length = 38 km

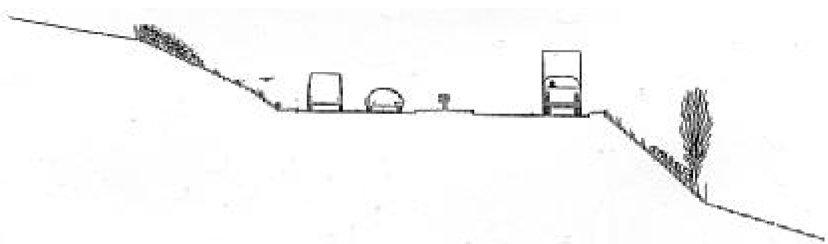


Figure 4.9 *Typical cross-section of a dual carriageway (A38, A380, A30, + other short lengths). Typical width excluding verges = 21m. Total length = 165 km (including 8.5 km opened in 1988 and 22 km opened in 1993)*

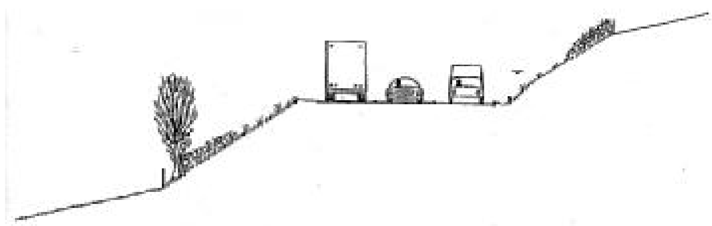


Figure 4.10 *Typical cross-section of a modern A road (A361/A39 + other short lengths).*
Typical width excluding verges = 9-13m. Total length = 67 km (opened in 1987-88)

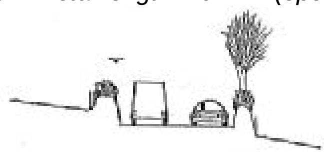


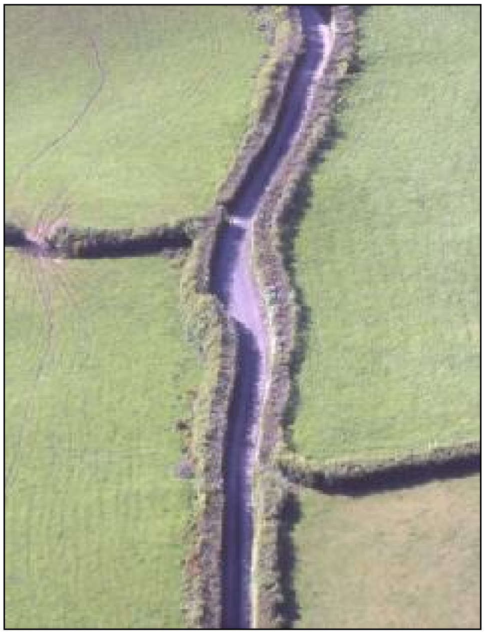
Figure 4.11 *Typical cross-section of a Traditional A/B road.*
Typical width excluding verges = 6m. Total length = 1,521 km

Figure 4.12 *Typical cross-section of a country lane.*
Typical width excluding verges = 3m. Total length = 12,959 km

The verges of all major roads (motorway, dual carriageway and modern A road) are dominated by r ough vegetation that normally includes areas of rough grassland, scrub (bramble/gorse/young trees) and young woodland (small/medium size trees). Where major roads cross flat landscapes the verges are comparatively narrow. However, most of Devon is hilly and verges alternate frequently between positively/negatively inclined and wide/narrow.

The verges of minor roads are dominated by Devon hedgerows that consist of an earth bank 0.5 -2 metres high topped with scrub. Most Devon hedgerows are annually cut to a height of 2-3 metres. Isolated hedgerow trees are frequent in some areas and a minority of hedges have been allowed to mature, forming narrow strips of dense woodland. However in many parts of Devon, hedgerow trees are infrequent. Scrub, annual flowering plants, ferns and brambles dominate typical Devon hedgerows. In a few areas hedge banks adjacent to minor roads are exceptionally high and dominated by rough grass. Occasionally, minor roads are bordered by narrow rough grass road verges with a fence or he dgerow. However, typical hedgerows, affording little if any rough grass, border the vast majority of minor roads.

Minor Roads



Country Lane

Traditional A/B Road

Photos both pages: David Ramsden

Major Roads

Modern A Road

Dual Carriageway

Motorway

Chapter 5 - Barn Owl Dispersal and Mortality: a Comparison Between Devonian and British Barn Owls

5.1 Summary

In the period 1985 – 1999, 976 Barn Owls were BTO-ringed, mainly by the Barn Owl Trust, in the county of Devon. 255 ring recoveries were recorded by the Trust or notified by the British Trust for Ornithology. The distance, direction, duration and finding circumstances were examined in order to determine the extent to which the behaviour of Devonian Barn Owls was typical of the British population as a whole. Similarly the seasonal pattern of reported Barn Owl mortality in Devon was examined and compared to British data. In almost every respect the Devon data was very similar to the national data. The only apparent difference was a possible lack of a late winter peak in adult Barn Owl mortality in Devon. The seasonal pattern of first-year mortality in Devon was almost identical to British data.

Overall, no significant differences were found and it is suggested that investigations based on Barn Owls in Devon are generally applicable to British Barn Owls.

5.2 Background

The overall aim of the Barn Owl Trust Major Road Research Project was to increase knowledge of the influence of major road networks on Barn Owls in Britain (see 1.5). However, the data used was gathered mainly in the county of Devon (see Chapter 4) rather than nationally. Given the relatively mild climate in the southwest, there may, for example, have been temporal or causal differences in dispersal or mortality. Thus, before using Devonian Barn Owl data, it was considered important to compare its characteristics with results derived from investigations based on national data sets. In this way the extent to which the results of the report in hand may be generally applied to British Barn Owls was assessed.

5.3 Methodology

For the Devonian sample, two data spreadsheets were produced. The first contained ringing and recovery details separately for each bird and the second contained ringing and recovery details separately for each ringing location. From this the numbers ringed at each location and subsequently recovered, as well as the locations themselves, were examined to ensure that there were no geographical biases in the data set. In spreadsheet 1 the following birds were excluded: birds that were not both ringed and recovered between 1985 and 1999 inclusive; birds that were not ringed in Devon; those that failed to fledge; those that were captive-bred or rehabilitated and released as adults. Subsequent broods from released captive-bred adults were included but identified. These had been free to leave the nest as normal wild birds. Spreadsheet 2 exclusions were the same, with the addition of those that were not ringed as pulli.

For each recovery in Spreadsheet 1 the finding date was entered and although the exact date of death was not always known, most birds were reported as being freshly dead, particularly road casualties and it was assumed that the finding date was close to the actual date of death. The month of finding for each bird was then assumed to be the month of death and calculated simply from the finding date. For each ring-recovery the distance and direction travelled from ringing place to recovery site was calculated along with the time duration. Direction was split into four categories: 0°-89° (N-E), 90°-179° (E-S), 180°-269° (S-W) and 270°-359° (W-N). Those birds that were ringed and recovered in the same place were excluded from the direction calculations. First-year birds at death were those that had been ringed as pulli with a duration of less than 365 days and the remainder were identified as adults. It should be noted that pulli were ringed between three and eight weeks old, therefore duration was not a precise measure of age. All captive-bred birds released as adults were excluded. All re-traps and controls were also excluded.

BTO ringing a juvenile Barn Owl – Photo: Muzz Murray

Recovering a casualty – Photo: David Ramsden

5.4 Results

Considering all 255 ring recoveries, the birds' sex was recorded in 113 cases, of which 52 were males and 61 were females. Table 5.1 shows the dispersal distances for Barn Owls ringed as pulli, comparing a sample from across Britain (taken from Bunn *et al*. 1982) with the Devon sample. The distribution of distances are highly skewed for all of the subsets, with most birds travelling less than 10 km and in all cases, over 85% travelled less than 50 km. A more recent analysis of all BTO data gave the f ollowing figures for first-years: 88.9% at 0-50 km, 6.7% at 51-100 km and 4.4% at >100 km and almost identical figures for adults (Wernham *et al.* 2002). Overall there is a remarkable similarity in the dispersal distance patterns between Barn Owls in Devon and those across Britain. The mean distance moved by first-year Devonian Barn Owls was 11.3 km, which compares well with the British figure of 11 km given by Percival (1990) for recoveries at 3-12 months old,and the median natal dispersal distance of 12 km given by Wernham *et al* (2002).

Distance (km)	British Barn Owls: % of first-year recoveries (n=285)	British Barn Owls: % of adult recoveries (n=184)	Devon Barn Owls: % of first-year recoveries (n=156)	Devon Barn Owls: % of adult recoveries (n=43)
0 - 10	61.5	53.3	55.1	46.5
11 - 50	30.9	37	37.8	39.5
51 - 100	5.3	4.9	5.1	9.3
101 - 200	1.7	4.3	1.3	2.3
201 - 300	0.3	0.5	0	2.3
Over 300	0.3	0	0.6	0

Table 5.1. *Recovery distances (natal site to finding place) of British Barn Owls (Bunn et al., 1982) and Devon Barn Owls. In each case first-year recoveries have been separated from those of adults and their respective percentages in each distance category are shown.*

Table 5.2 shows the timing of juvenile dispersal away from natal sites. The median dispersal distance before recovery is given for each 30-day period after ringing. Again, the British (BTO) sample, this time using natal site to breeding site, is compared to the Devon sample. There is a remarkable degree of agreement in the dispersal distances between British and Devonian Barn Owls. Dispersal starts after approximately 30 days and appears to have been completed within 180 to 210 days, after which it is constant or slightly declining.

Time period after ringing (days)	British Barn Owls		Devon Barn Owls	
	Sample size	Median distance (km)	Sample size	Median distance (km)
0-30	46	0	20	0
31-60	166	3	19	4
61-90	244	7.5	16	10
91-120	182	11.5	22	12
121-150	179	12	16	15
151-180	157	14	16	14
181-210	158	13	11	17
211-240	144	12	17	10
241-270	112	15	8	10
271-300	66	9.5	10	10
301-330	44	13	0	-
331-360	22	12	6	16

Table 5.2. *Juvenile dispersal of Barn Owls ringed as pulli in Britain compared to Devonian -ringed pulli, expressed as the median recovery distances recorded in each 30 day period following ringing.*

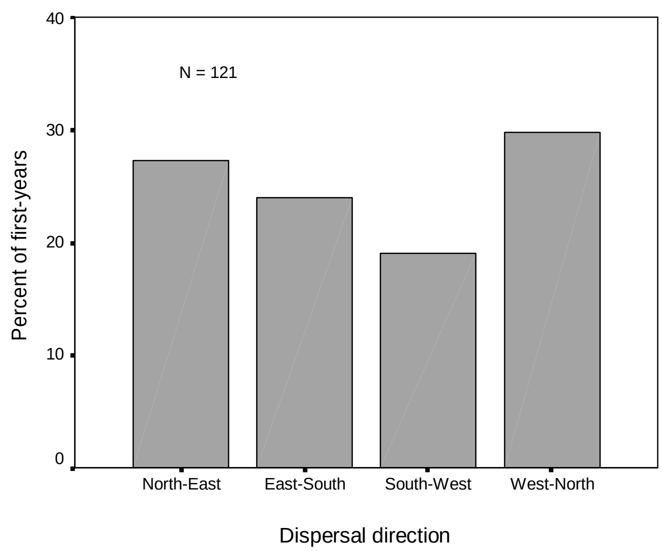


Figure 5.1. *The dispersal directions of Devonian Barn Owls ringed as pulli, expressed as the percentage of all recoveries that were reported within each 90 ° arc. Only birds that moved were included.*

Figure 5.1 shows the dispersal directional pattern for all Devonian Barn Owls ringed as pulli and recovered in their first-year, with the exclusion of controls and those that did not move. Dispersing birds showed no significant association with direction ($X^2 = 3.13$, *df* = 3, *NS*).

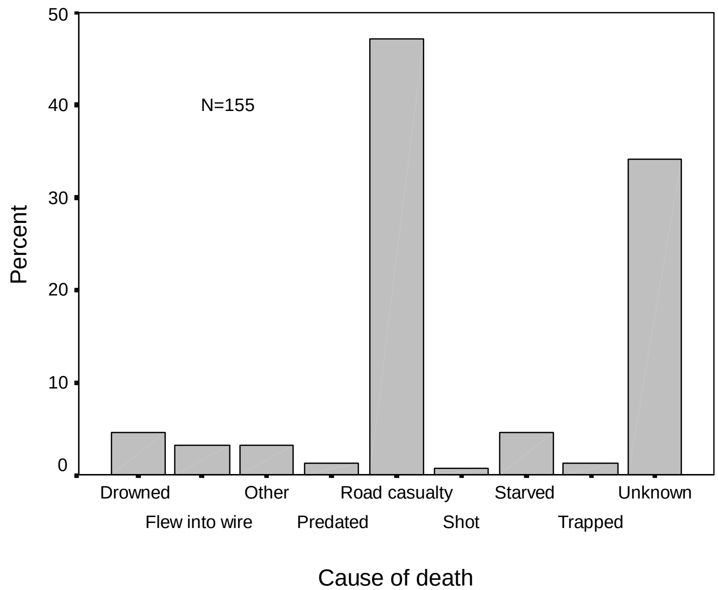


Figure 5.2. *Finding circumstances of first year Barn Owls expressed as percentages of all recoveries of birds ringed as pulli in the county of Devon in the period 1985 – 1999.*

Figure 5.2 shows the finding circumstances of first-year Devonian Barn Owl casualties. Road victims were by far the most commonly reported, comprising 47% of all deaths, although 34% were of unknown cause. Other finding circumstances were all of relatively low percentages.

Figure 5.3 shows the finding circumstances for adult Devonian Barn Owl casualties. Again, road victims were by far the most common, comprising 51% of all deaths, with 37% of unknown cause. Other causes were of relatively similar percentages. Overall, the reported finding circumstances of adults were very similar to first-years, although no adults were reported as drowned, shot or trapped and the percentage of road casualties was slightly higher.

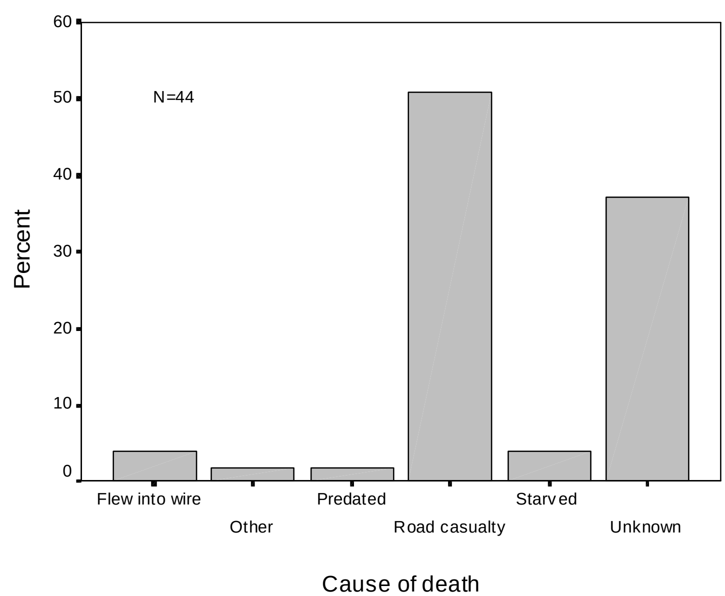


Figure 5.3. *Finding circumstances of adult Barn Owls expressed as percentages of all recoveries of birds ringed as pulli (and recovered more than one year old) in the county of Devon in the period 1985 – 1999.*

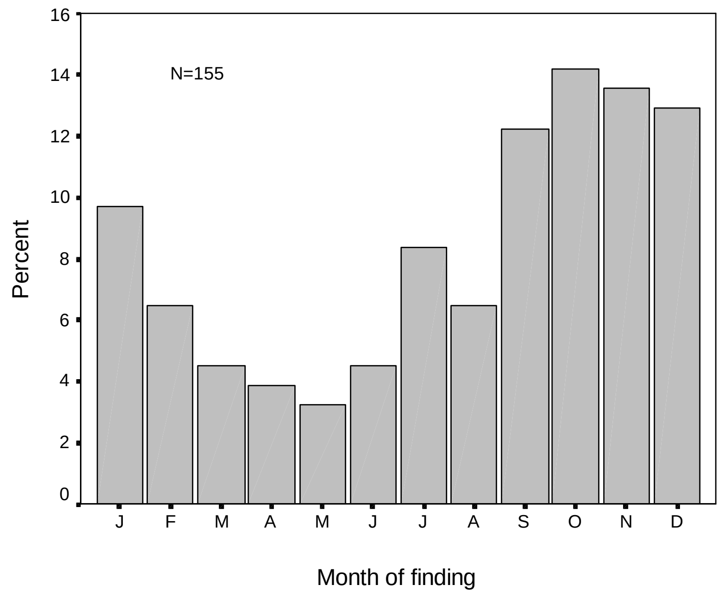


Figure 5.4. *The seasonal distribution of ring-recoveries of first-year Devonian Barn Owls ringed as pulli, expressed as percentages of all ring-recoveries in this age class.*

Figure 5.4 shows how the first-year recoveries were distributed between months. The numbers of deaths were clearly highest in autumn, declined through winter and lowes t in early summer. Adult recoveries (Fig. 5.5) were more evenly distributed through the year but generally less frequent in summer.

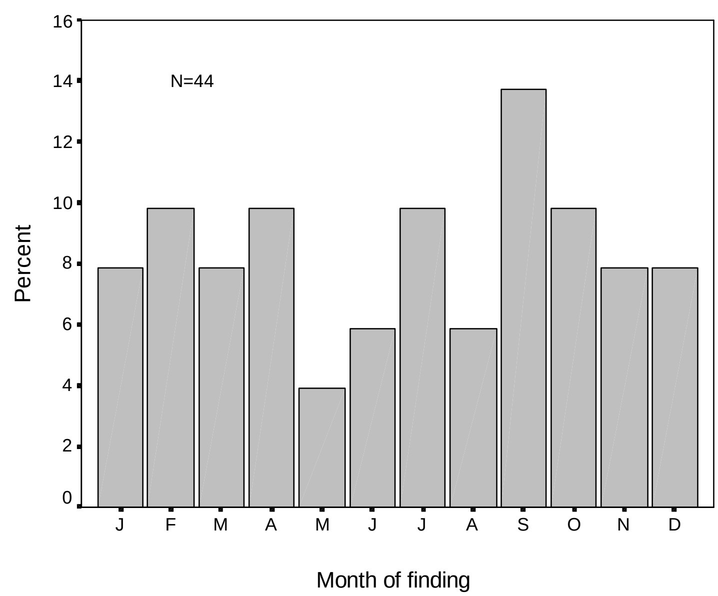


Figure 5.5 *The seasonal distribution of ring-recoveries of adult Devonian Barn Owls ringed as pulli, expressed as percentages of all ring-recoveries in this age class.*

5.5 Discussion

5.5.1 Are Devonian Barn Owl dispersal patterns typical of British Barn Owls?

The dispersal distances of Barn Owls ringed in Devon show a very similar pattern to those of British Barn Owls. It should be noted that the two data sets are from differing time periods. The exact time period of the BTO data (in Bunn *et al*. 1982) was not clear, but it was certainly collected before the Devon data. Also, there were likely to have been some Devon-ringed Barn Owls within the BTO data set so the two data sets were temporally, but not spatially, independent.

The data presented on the timing of juvenile dispersal in Devon was produced using reported recoveries of casualties and the national data from the BTO presented in the Migration Atlas (Wernham *et al.* 2002) was produced in the same way, so that they are directly comparable (M. Toms personal communication). However, it should be noted that the two data sets are not entirely independent, as the British data includes most of the Devon data. As with dispersal distances, the evidence indicates that the timing of Barn Owl dispersal in Devon is similar to Britain as a whole.

A recent analysis of all BTO ring recovery data showed that, within Britain, dispersal direction is random (Wernham *et al.* 2002). In this respect, Devonian Barn Owls were typical of British Barn Owls.

5.5.2 Is the mortality of Devonian Barn Owls typical of British Barn Owls?

The finding circumstances of Devon-ringed Barn Owls, both first-years and adults, showed a very similar pattern to those described by other authors. Newton *et al*. (1997) and Shawyer (1987) showed that, across Britain, road mortality was the most commonly reported cause of death, although these studies were not based on ring recoveries. Using BTO ring recovery data recorded in the period 1983 to 1988, Percival (1990) showed that 31% of first-year recoveries were reported as "unknown", 49% as "traffic" and all other finding circumstances were infrequently reported (the figures for Devon were 34% and 47% respectively). Considering adults, the British data gives 37% unknown and 40% traffic (Devon, 37% and 51%). Again, the strong similarity between Devonian and British Barn Owls is evident. It should be noted that the two datasets were not entirely independent and that both were subject to the same biases (birds dying in conspicuous places are more likely to be reported, see 1.3.1, A1.1, A1.10).

The seasonal pattern of first-year reported mortality in Devon was similar to that presented by various authors, from post mortems (Newton *et al*. 1997), from anecdotal records (Shawyer 1998) and from loss of individuals and systematic corpse searches in an intensive study area (Taylor 1994). The monthly pattern of first-year-mortality in Devon was strikingly similar to the data presented by Percival (1990) based on ring recoveries throughout the British Isles.

Although the seasonal pattern for British adults generally shows less variation than for first-years, a peak is usually evident between January and March, which are the coldest months (Newton *et al*. 1997; Shawyer 1998; Taylor 1994). British ring-recoveries also show the same pattern of adult mortality, that is, a marked late winter peak (Percival 1990). Although the Devon data suggested that mortality in summer was lower than in other seasons, it did not show a prominent late winter peak (see Fig. 5.5). This may have been a consequence of sample size, as the Devonian data contained only 50 adult recoveries in this analysis. An alternative explanation is that over-winter survival in Devon may be better where winters are milder than in many other parts of Britain. This discrepancy warranted further investigation.

Using the British Barn Owl ring-recovery dataset, Percival (1990) examined regional and age-related trends in survival. He showed that in the years 1986-1987 adult survival in SW England was very similar to survival in other regions (p.57). Using recovery data gathered over a much longer period (1944-1988), adult survival across Britain was 63% and in SW England/Wales it was almost identical (64%). This suggests that adult survival in the milder southwest does not differ from Britain as a whole. It is therefore suggested that either adult winter mortality in Devon was typical of Britain (the apparent difference being caused by sample size), or, it is slightly lower, perhaps lower than overall mortality within the SW England/Wales region.

Chapter 6 – Barn Owls Encountering Roads: A Comparison Between Road Types Based on Reported Sightings of Live Birds and Casualties

6.1 Summary

Throughout a fifteen year period the Barn Owl Trust collected well over a thousand random reports of live Barn Owls, most of which were seen from roads and 181 road casualties. Each of these was assigned to a particular road type. The study area (Devon) had a very high road density across the entire (lowland) area. Of the 14,750 km of roadway, 98.3% was minor road and 1.7% was major road (motorway, dual carriageway and modern A road), totaling 245 km.

The likely biases contained in this type of data were reviewed in detail. It was highly likely that major road casualties were under-recorded. In spite of this 3.6 deaths per year were reported for every 100 kilometres of motorway, compared to only 0.008 deaths per year, per 100 km on country lanes.

Overall, Barn Owls reported from minor roads were fifty-seven times more likely to be reported alive than reported dead. A Barn Owl reported from a major road was three times more likely to be reported dead than reported alive. The conclusion drawn is that minor roads were unlikely to affect Barn Owls to any extent, either positively or negatively, but when individual Barn Owls encountered a major road they very quickly became casualties, or otherwise disappeared. The evidence also suggests that major roads are not used as dispersal corridors by Barn Owls.

6.2 Background

6.2.1 Other studies

There is a general lack of information on the effect/s of different types of roads on Barn Owls. In the context of owl road mortality, most authors refer only to motorways/autoroutes and dual carriageways (see, for example, Bourquin 1983; De Bruijn 1994; Baudvin 1997; Massemin & Zorn 1998; Shawyer & Dixon 1999). The assumption may be made that most authors do not mention minor roads because they do not find many casualties there, but the chance of casualties being found may vary between road types (see A1.10) and most research on Barn Owl road mortality was based on intentional searches for corpses along major roads only (see A1.2). The only study that compared Barn Owl mortality on different road types (Illner 1992) was carried out in a very small study area of 125 sq km in Germany.

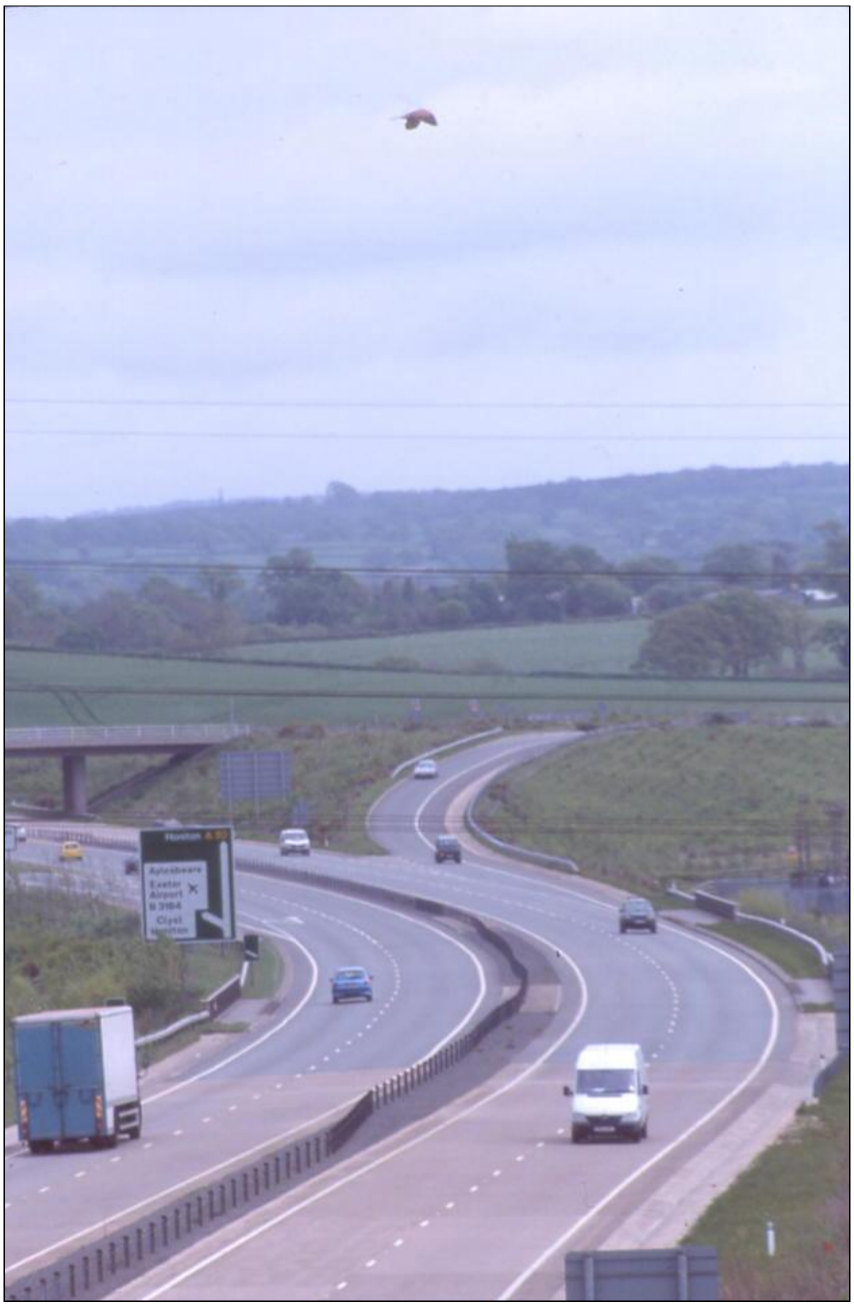
Illner (1992) classified roads according to a combination of type and traffic speed (categorized simply as over or under 80 km/h) and calculated the number of Barn Owl casualties per 100 km per year for each road class. Unfortunately, no description of the physical characteristics of the various road types was given. On approximately 100 km of road with car speeds of less than 80 km/h (minor road?) no Barn Owl casualties were found. Conversely, on the 16 km of trunk road where speeds regularly exceeded 80 km/h 13 were found. In an intermediate road category 70 km in length described as "other road" (not trunk) where speeds exceeded 80 km/h, another 13 were found. The author stated *"on roads with car speeds regularly greater than 80 km/h about 21 times as many owls (inc. Barn Owls) were killed by cars as on the other roads. Road death rates appeared to be little affected by the density of traffic. Speed of vehicles appeared to be more important"*.

The suggestion by Illner (1992) that traffic speed is a more important factor than traffic density is often quoted by authors (eg.Taylor 1994). In his paper, Illner (1992) named six previous studies that had suggested speed was important and pointed out that none of these studies quantified traffic speed and separated it from traffic density. He then suggested that speed was indeed more important than density without quantifying density and only quantified speed as above or below one arbitrary value (80 km/h).

Because Illner (1992) did not specify the physical characteristics of the roads, it is not possible to determine to what extent mortality may have been a result of road type rather than traffic speed.
In addition, Illner (1992) did not mention the probable inter-road-type biases involved in his data (see A1.10) or determine the possible effect of other factors, such as traffic type or road verge habitat/management.

The extent to which individual Barn Owls frequent roads (and road verges) is another interesting subject area about which very little is known. With regard to major roads with rough grass verges, numerous authors have suggested that Barn Owls are attracted to forage along the verges (see A1.6) and one study suggested that juvenile Barn Owls might use verges as dispersal corridors (see A1.7), although there is little or no evidence to support this. Kestrels are well known for hunting beside major roads and drivers observe them hovering high above the verges. In spite of the fact that they are much more noticeable, Barn Owls are <u>not</u> known as “those big white birds seen along major roads at night” which suggests that they tend not to frequent such places (see A1.5).

Of all the Barn Owl road research carried out, only one study collected reports of live Barn Owls seen from a road. Shawyer & Dixon (1999) appealed for reports of live sightings along a 50 km stretch of major road over a three year period and searched for casualties (see A1.6). The live sightings reported by the public (n=56) and casualties found by intensive search (n=102), suggested that the birds were far more likely to be found dead than reported alive. However no firm conclusions can be drawn because of extreme differences in observer effort between categories. To date, no studies have investigated the frequency of reported sightings from different road types, or compared the frequency of live and dead sightings of Barn Owls on roads.



Kestrels are well known for hunting beside major roads and drivers observe them hovering high above the verges. In spite of the fact that they are much more noticeable, Barn Owls are <u>not</u> known as “those big white birds seen along major roads at night” which suggests that they tend not to frequent such places

Photo: David Ramsden

6.2.2 The Barn Owl Trust's data

Owing to their size, low flight and predominantly white coloration, Barn Owls are highly noticeable but due to the species' crepuscular/nocturnal habits and rarity, they are unlikely to be seen. Indeed, very few people frequently see Barn Owls. Therefore, a large sample of reported sightings can only be collected in large areas over long time periods. During the period 1985 to 1999, the Barn Owl Trust recorded every live sighting of Barn Owls reported to the Trust by the public in the county of Devon. Each observation was recorded to an accuracy of 100 metres, using a six figure OS map reference and the exact position was often noted. Due to possible confusion with Tawny Owl (*Strix aluco*) the reporter was always asked to confirm that the bird seen was correctly identified and all doubtful reports were excluded. Thus, a unique database of reported live sightings over a fifteen -year period across an entire county was created.

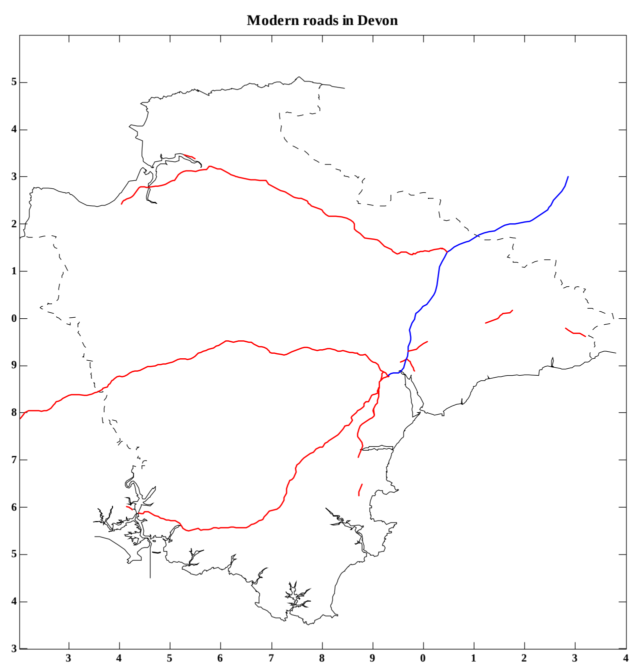
In addition to live birds, casualty Barn Owls were also reported to the Trust by the public and in many cases the reporter had picked up the bird and some of these were BTO ringed. Reports to the Barn Owl Trust of ringed casualty Barn Owls were relatively commonplace. In addition to the normal information collected from finders, the exact finding place and the road number and type were recorded in every case. In cases where the report came via the BTO, the Barn Owl Trust contacted the finder for additional details, since BTO ring recovery data was not precise enough for our purposes. Hence, both ringed and unringed birds were recorded in detail. Both live and dead sightings were made by chance and reports were, therefore, not fundamentally biased in the way of Shawyer & Dixon's A303 data (see above).

As the data accumulated over the fifteen-year period, it became evident that reported live sightings and reported casualties were not evenly spread across road types.

6.2.3 Devon roads

Devon has a high road density, with 14,750 km of roads in an area of 6,711 square kilometres (Devon County Council personal communication). Almost every square kilometre contains one or more roads, with the exception of upland areas where Barn Owls rarely occur. In Devon, country lanes are so densely distributed that virtually every Barn Owl must cross them both frequently and repeatedly. With the exclusion of urban roads, Devon's roads can be divided into two basic types: major and minor (see 4.3). Minor roads represent 98.3% of the total length. Although major roads account for only 1.7% of the total length they are well distributed across the county (see map 6.1).

Note: The only significant new roads constructed and opened during the study period were the A30 dual carriageway from Okehampton to Liftondown in west Devon (8.5 km in 1988 and 22 km in 1993) and the A361/A39 modern 'A' road in north Devon (66 km in 1987-89).



Map 6.1 *The network of major roads (motorways, dual carriageway and modern 'A' roads) in the county of Devon in 1999.*

6.3 Aims

1) To compare the frequency of live and dead Barn Owl reports for each road type.
2) To review the likely effect of all probable biases in the data.
3) To gauge the extent to which Barn Owls encounter roads of various types.
4) To summarise how different road types may affect Barn Owls that encounter them.

6.4 Methodology

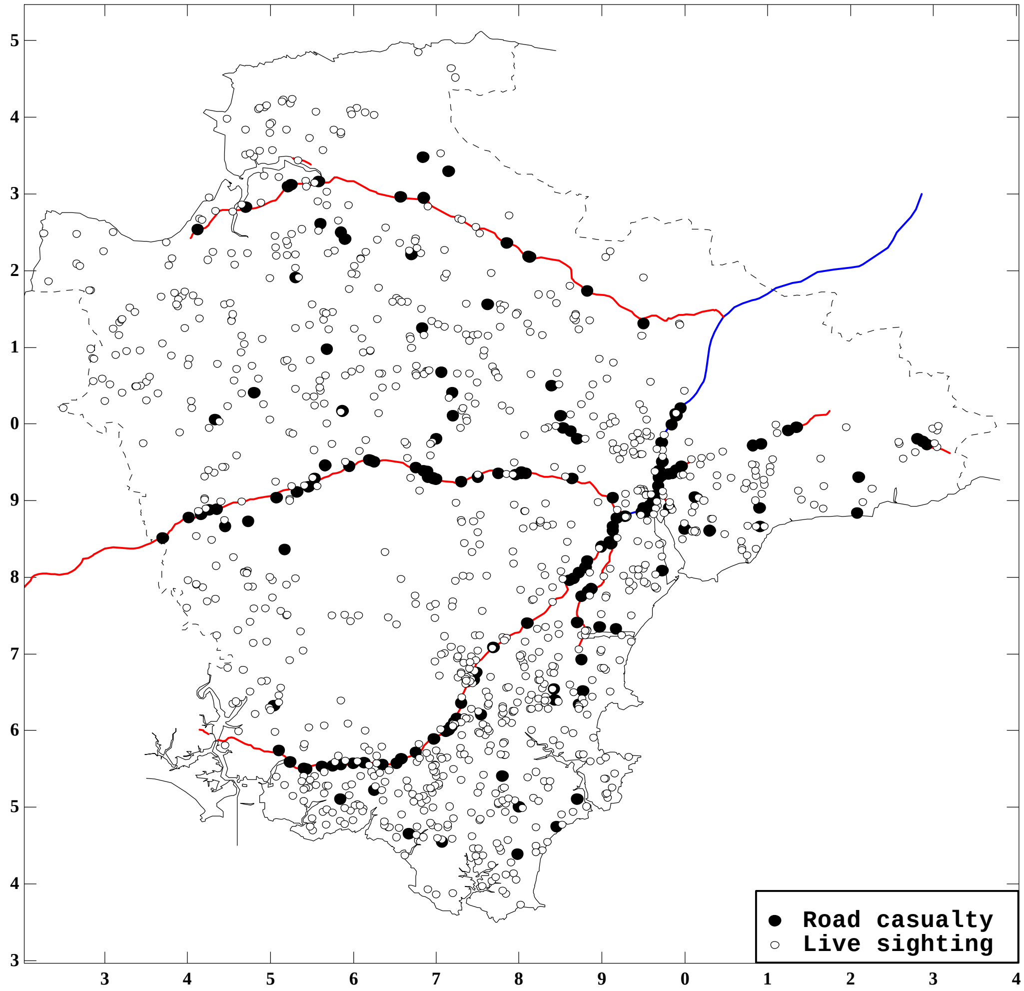
For each of the 1,138 sightings of live birds, the distance from the nearest road, of any type, was measured and all those reported at more than 100 metres from a road were exclude d. Thus, the remaining 947 reports were of birds which were either recorded as seen from a road, assumed to be seen from a road, or could have been seen from a road. Where the recorded map reference was on a roadway, the type was noted. In all other cases the type of road that predominated within 100 metres was selected (normally only one type occurred).

The Barn Owl casualty data set comprised 255 BTO ringed (all causes) and 102 unringed (road casualties). All non-road recoveries were excluded along with four cases of unknown road type. All ringed birds that were captive bred or rehabilitated and released as adults were also excluded. This left a sample size of 181 road casualties (102 unringed and 79 ringed).

The number of live Barn Owls and the number of casualties reported per 100 kilometres per year on each of the four road types during the study period was calculated. The total road lengths used were average figures over the 15-year study period. For example, if a new section of road had been opened (see 6.2.3) exactly half way through the study period only half its length would have been included in the total road length for its class.

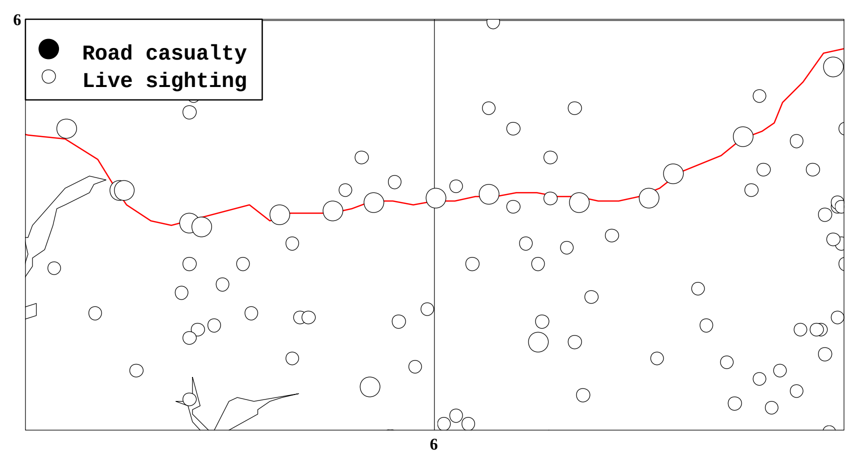
6.5 Results

Most live sightings reported by the public were of birds that were only seen once and most of these w ere *seen whilst driving.* Most reported casualties were also *seen whilst driving* and were picked up dead. Map 6.2 shows the distribution of both live and casualty sightings across the study area in relation to the distribution of major roads. It is evident that live sightings from roads are well distributed across most of the county whereas road casualties tend to be concentrated on major roads.



Map 6.2 *The distribution of reported live sightings of Barn Owls seen within 100 metres of roads and the distribution of all reported casualties on roads in the period 1985 -1999 in the county of Devon.*

Note: two new sections of the major road shown were opened part way through this period (see 6.2.3).



Map 6.3 *The distribution of reported live sightings of Barn Owls seen within 100 metres of roads and the distribution of all reported casualties on roads in the period 1985 -1999 in the two ten kilometre squares to the east of Plymouth (SX55 and SX65).*

Due to the limitations of scale, map 6.2 does not illustrate the proximity of live sightings to major roads in any detail. Zooming in on two ten kilometre squares (map 6.3) reveals that whilst casualties on major roads were relatively common, live sightings on major roads were very unusual. Table 6.1 shows the figures for live sightings and road casualties reported in the entire county. Of the 38 live sightings of birds seen on or from major roads, 17 were isolated and the rest were grouped into seven place clusters (some containing duplicate map references) averaging three sightings per cluster. Three of the seven place clusters were also closely date clustered.

Of the Barn Owls reported from major roads, 24% were alive and 76% were casualties. From minor roads, 93.5% of birds reported were alive and only 6.5% were casualties.

	MINOR ROADS		**MAJOR ROADS**		
	country lanes (12,960 km)	traditional A/B roads (1,544 km)	modern A roads (54 km)	dual carr. & motorways (191 km)	Total (14,749 km)
Live sightings	740	169	9	29	947
Road Casualties	16	47	14	104	181

***Table 6.1**. The number of reported live Barn Owl sightings within 100 metres of a road and road casualties on each of the four road types in Devon during the period 1985 to 1999. Total length of each road type is given in brackets.*

When the total length of each road type is taken into consideration, the frequency of live sightings on major roads was higher than for minor roads (see fig. 6.1). However, live sightings were biased towards major roads (see discussion).

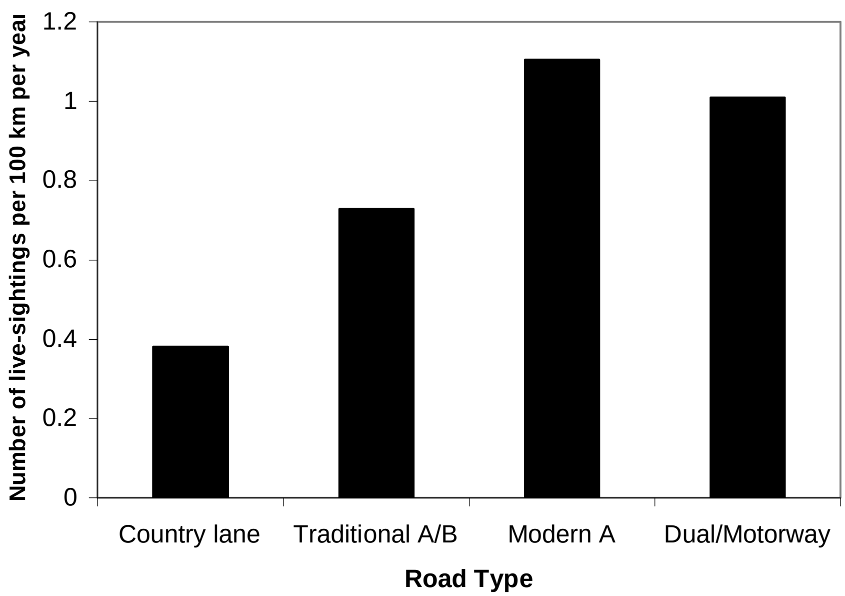


***Fig. 6.1**. Numbers of live Barn Owl sightings per 100 km of road per year in Devon in the period 1985 to 1999 inclusive.*

Considering casualty Barn Owls, figure 6.2 shows the numbers reported between 1985 and 1999 per 100 km of road per year on the four different road types. Dual carriageways/motorways had the highest number by far, followed by modern A roads, followed by traditional A and B roads. Country lanes yielded proportionally the smallest numbers of casualties.

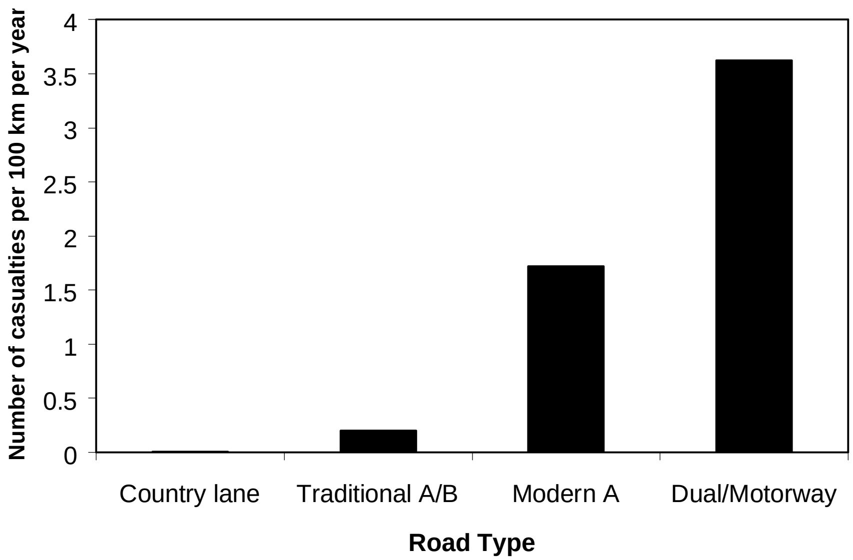


***Fig. 6.2**. Numbers of casualty Barn Owls reported in Devon on each of the four road types per 100 km per year in the period 1985 to 1999 inclusive. Both ringed and non -ringed casualties are included.*

There was a highly significant association between certain road types and the type of Barn Owl sighting reported (χ^2 = 529.8, *df* = 3, *P* < 0.01). A four-by-two contingency table of road type against live and dead reports was used. When the individual χ^2 components were examined it was found that the greatest value was for dead Barn Owl reports on dual carriageways/motorways, followed by dead-reports on country lanes, followed by live-reports on dual-carriageways/motorways. There were more dead-reports on dual carriageways/motorways than expected, fewer dead-reports on country lanes than expected and fewer live-reports on dual-carriageways/motorways than expected.

6.6 Discussion and Review of Biases

6.6.1 The frequency of live and dead reported Barn Owl sightings for each road type

Despite the fact that individual χ^2 tests could not be done, the frequency of reported Barn Owl casualties clearly increased significantly between each one of the four road types. Both in terms of total numbers and numbers per length per year, the majority of reported casualties were on major roads. The frequenc y of live-sightings only increased slightly between road types and was just highest, on modern ‘A’ roads. However, the chances of a Barn Owl being seen and subsequently reported on any particular type of road were very likely to be biased.

It is well known that data collected through chance observations and casual reports can contain significant biases. For example, a bird lying in a highly conspicuous place is far more likely to be noticed. For a general discussion of biases in Barn Owl mortality data see *Introduction* (1.3.1). For a general discussion of the factors that might affect the chances of any road casualty being reported, see A1.10.

Although somewhat subjective, it is important to assess critically the probable influence of each expected bias before attempting to interpret the significance of the results.

6.6.2 Examination of probable biases

a) Observer effort
Major roads, especially motorways and dual carriageways, generally carry a higher density of traffic than minor roads, therefore driver and passenger density will be higher. The much greater number of observers per road length on major roads means that reported sightings are almost certainly strongly biased towards major roads.

b) Road visibility
Minor roads, particularly country lanes in Devon, are generally narrow and wind their way though the countryside with a high degree of curvation and undulation. This, plus the presence of roadside hedgerows and trees, severely limits visibility. Thus, during night driving on minor roads, the ill uminated area is relatively restricted; often only the foreground is well illuminated. Major roads are much wider and straighter with gradual sweeping bends giving excellent visibility, so the illuminated area is greater. In addition, on multi-lane roads, the headlights of other vehicles moving in the same direction greatly increase the total illuminated area. The much better visibility on major roads means that reported sightings are almost certainly biased towards major roads.

c) Vehicle speed
Observers may be less likely to notice a Barn Owl if they are driving at high speed. This may be particularly true of corpses. The lower average speed of vehicles on minor roads means that sightings, both dead and alive, are probably biased towards minor roads.

d) Owl visibility
The chances of a bird being seen must depend on its appearance. Road casualty Barn Owls are usually picked up with their wings folded. Less often they are picked up with one or both wings slightly open or as a flattened "pancake" in a traffic lane. The coloration of a dead Barn Owl blends in well with the grey road surface, brownish grass verges and the predominantly white/brown litter discarded from vehicles on major roads. The reported sightings of live Barn Owls seen from roads were almost always birds in flight and these were most often reported as appearing large and predominantly white. The visible surface area of a flying Barn Owl is several times greater than a typical casualty. In addition, the height and movement of live birds may help to attract human attention. Overall, reported sightings of Barn Owls may be biased towards live birds because of their visibility. However this factor probably does not vary between road types.

e) Temporary versus permanent visibility of live and dead birds
A live Barn Owl encountering a road may only be present for a matter of seconds or minutes. Conversely a dead Barn Owl lying on the road or verge may be constantly visible until someone or something removes it. Sightings may be biased towards casualties simply because most casualties are present and visible for a longer period than most live birds. However this factor probably does not vary between road types either.

f) Continuous high speed of vehicles
Due to its size and lightweight, a Barn Owl struck by a vehicle may be carried on the vehicle until it drops off when the vehicle slows down or stops. (For a general discussion of the accidental transportation of corpses, see A1.11). The greater speed of vehicles on major roads means that birds s truck on major roads are probably more likely to be transported. Vehicles on major roads maintain a fairly constant high speed, whereas vehicles minor roads frequently slow down and stop at junctions. Therefore the distances involved in accidental transportation must be greater on major roads. If transportation is a common occurrence, a proportion of casualties should be reported from major road exit slip roads and associated junctions. However such reports are rare. For the purpose of this investigation, t ransportation could not bias the data to any extent unless it was transferring a significant number of corpses between major and minor roads. This is most unlikely.

g) Prohibition of vehicle stopping and danger to pedestrians
Modern 'A' roads and dual carriageways are usually designated as "clearways" and motorways have special regulations. Stopping any vehicle on these roads other than in designated parking areas is prohibited by law in both cases. Although some observers obviously do stop to pick up casu alty birds on these types of road, information about collected road casualties is probably biased towards minor roads, which are generally considered less dangerous to walk on. Reports of casualties identified without vehicle stopping are unlikely to be biased in this way. Overall, reports of casualties are probably biased away from major roads to some extent.

h) Scavenger effort

If scavengers take dead Barn Owls from the roads, this would greatly reduce the chances of them being reported. Corvids are well known for feeding on road casualties but are not normally seen carrying off the whole body of Barn Owl-sized casualties. It is likely that foxes (*Vulpes vulpes*) are capable of removing casualties from roads, but the extent to which this may occur and the possible effects on casualty Barn Owl corpses on different road types is unknown.

6.6.3 The likely combined effect of biases

	Major Roads	Minor Roads
Casualty Barn Owls	• difficulty, danger and illegality of stopping • higher vehicle speed - less time to notice? • ignored amongst litter • <u>but</u> more observers & greater visibility <u>overall - relatively **UNDER** recorded</u>	• easier, safer and legal to stop • lower vehicle speed – more time to notice? • much less litter – more obvious • <u>but</u> fewer observers <u>overall - relatively **WELL** recorded</u>
Live Barn Owls	• much greater visibility • more observers • <u>but</u> higher vehicle speed - less time to notice? <u>overall - relatively **WELL** recorded</u>	• less visibility • fewer observers • <u>but</u> lower vehicle speed – more time to notice? <u>overall – relatively **UNDER** recorded</u>

Table 6.2 *A summary of the probable relative effects of the various biases which may affect the chances of live and casualty Barn Owls being reported as seen and/or picked up on major roads and on minor roads.*

In summary, Table 6.2 shows how biases were likely to result in live sightings being relatively well recorded on major roads and under recorded on minor roads and casualties being under recorded on major roads and well recorded on minor roads.

When compared to minor roads, the 65.6% of live sightings per 100 km/year on major roads may be an <u>over</u>-representation due to the biases above and the limitations of sample size (major roads represented only 1.7% of total road length and the numbers of sightings on major roads represented only 4% of all sightings). The 96.2% of reported casualties per 100 km/year on major roads is likely to be an <u>under</u>-representation.

6.6.4 Barn Owls and minor roads

As previously stated, virtually all Devonian Barn Owls must have crossed minor roads frequently, owing to the number and density of such roads in the county. In spite of relatively restricted visibility and low observer density, 740 sightings were reported from narrow country lanes, which represents a frequency of almost 0.4 reports per 100 km/year (see Fig. 6.1).169 sightings were reported from Traditional A/B roads at a higher frequency of 0.73 per 100 km/year, which may be accounted for by the slightly better visibility and observer density (volume of traffic) on these two-lane roads.

In Devon, most minor roads are bordered by hedgerows (see Chapter 4) and although Barn Owls may hunt along hedges, there is no reason to suppose they prefer the minority of hedges that border roads. Indeed, the fact that a bird was seen from a road does not necessarily mean that its presence had anything to do with the road. It is likely that many of the minor road sightings were of birds that were seen simply by chance (i.e. the observer was there because of the road, whereas the b irds' presence had nothing to do with the road). This view is supported by the fact that most of the reports were of birds *seen once*.

This was not always the case, however and a minority of reports referred to birds which were *regularly* seen from minor roads, either perched on roadside fence posts and/or hunting on adjacent land. Very few reports were considered to be birds actually hunting *along* the road itself (linear strips of prey -rich rough grass are not a common feature of minor roads in Devon). Very occasional reports were received of birds seen standing on the road surface and in such cases the bird apparently showed little inclination to move (for a discussion of this phenomenon see A1.8).

Minor road casualties were likely to be relatively well r ecorded (see Table 6.2), but in spite of this only 16 were reported on 12,960 km over the fifteen years, which represents only 8.8% of all reported casualties. Hedgerows in Devon are generally taller than most cars, thereby minimising the danger to a Barn Owl flying across. This, combined with the fact that the birds did not appear to concentrate their activity along minor roads, explains the relative rarity of minor road casualties. Overall, Barn Owls reported from minor roads were fifty-seven times more likely to be reported alive than reported dead. The evidence suggests that minor roads are unlikely to affect Barn Owls.

6.6.5 Barn Owls and major roads

It is evident from the number of Barn Owl casualties found on major roads that the birds certainly encounter them. The excellent visibility afforded by major roads means that Barn Owls flying across the road or along a verge would have been highly noticeable. In addition, the relatively high observer density (volume of traffic) would have strongly biased live Barn Owl sightings towards major roads. However, such reports were rare (see table 6.1). From 245 km of major road, there were only 38 reported live sightings in fifteen years.

Because the reported sightings were made by drivers/passengers on high -speed roads, they were always very brief. As such, it was not possible to determine whether the birds' presence was in any way related to the presence of the road, whether they were or were not foraging on the road verges. However, out of 38 live sightings, 20 were in seven clusters (multiple sightings in one place reported independently by several observers) and three of the seven clusters covered only a short time span. This suggests that places where sightings were clustered were perhaps places where bir ds either foraged on the road verges or regularly crossed, perhaps because the road crossed a regular farmland flight path. However, only seven clusters in 245 km suggests that this was not commonplace. Where reports of Barn Owls seen alive on major roads were both place and time clustered, it is probable that the bird/s did not frequent the road for long. There was certainly no evidence to support the suggestion by Shawyer and Dixon (1999) that Barn Owls use major roads as dispersal corridors (see A1.7). The marked lack of live sightings on major roads suggests they do not.

Illner (1992) calculated that in his small German study area, 21 times as many owls (all spp.) were killed per length per year on high-speed roads than on other roads. The same calculat ion for Devon shows an even more extreme difference with 111 times as many Barn Owls killed on major roads as on minor roads.

Casualties on major roads were likely to be relatively under -recorded in relation to both live sightings on major roads and casualties on minor roads. In spite of this, 118 casualties were reported, far more than were reported alive on major roads and far more than were reported dead on minor roads. It is also worth noting that major road casualties were not strongly place -clustered in the way that live sightings from major roads were (see Map 6.2). A Barn Owl reported from a major road was three times more likely to be reported dead than reported alive. The high number of reported casualties on major roads, nearly all of which were picked up, provided material evidence that Barn Owls frequently encountered major roads, whereas the lack of live sightings suggested that they did not. The conclusion drawn is that when individual Barn Owls encountered major roads they very quickly became casualties, or otherwise disappeared

Chapter 7 - Major Road Density Around Nest Sites and the Chances of the Young Produced Becoming Major Road Casualties

7.1 Summary

The investigation aimed to determine whether a relationship exists between the lengt h of major road close to a Barn Owl nest site and the probability of that site producing Barn Owl major road casualties. Only those sites where the number of pulli ringed was known were used and at these sites (n=128), a total of 891 young were ringed and 137 recoveries were reported.

For each site, the proportion of ringed birds that were reported as casualties on major roads and major road length within a 10 km radius, was calculated and checked for correlation. A positive relationship was found, but it did not explain the variance between sites in recorded major road mortality rates.

Overall, the method was found to be ineffective because most of the birds that became major road casualties did not disperse in the direction of the nearest major road, where major road density was measured. It is concluded that the probability of young from any given site becoming major road casualties could not be assessed by quantifying the density of major road within 10 km of the nest. A method that considered the proximity of major roads in all directions simultaneously may be more useful.
.

7.2 Background

When selecting areas in which to encourage Barn Owl population growth it would seem advisable to avoid land within close proximity of major roads due to the risk of road mortality. However, the possible effect of the presence of a motorway or dual carriageway or other major road on the mortality of local dispersing young has not been investigated. (For a discussion of the effects on nearby established adults see Chapters 2 & 3).

During the period 1985 to 1999 inclusive, the Barn Owl Trust monitored numerous Barn Owl nest sites throughout Devon. At many sites the pulli were BTO ringed annually. The proximity of the road did not influence the decision to ring birds at a particular site. Thus, the ringing sites were not intentionally biased with respect to the proximity of major roads.

7.3 Data Used

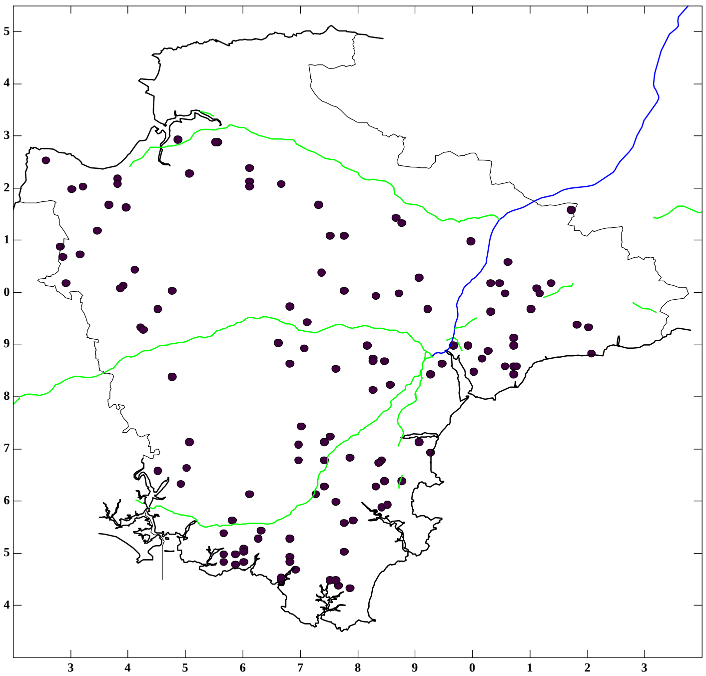
Only sites where the exact number of pulli ringed was known were used for this part of the analysis. The data comprised 123 of the Barn Owl Trust's own ringing sites plus 5 sites contributed by an independent BTO ringer (J Tallowin). At these selected sites a total of 891 young were ringed and, from these, 137 recoveries were reported over a fifteen-year period.

7.4 Methodology

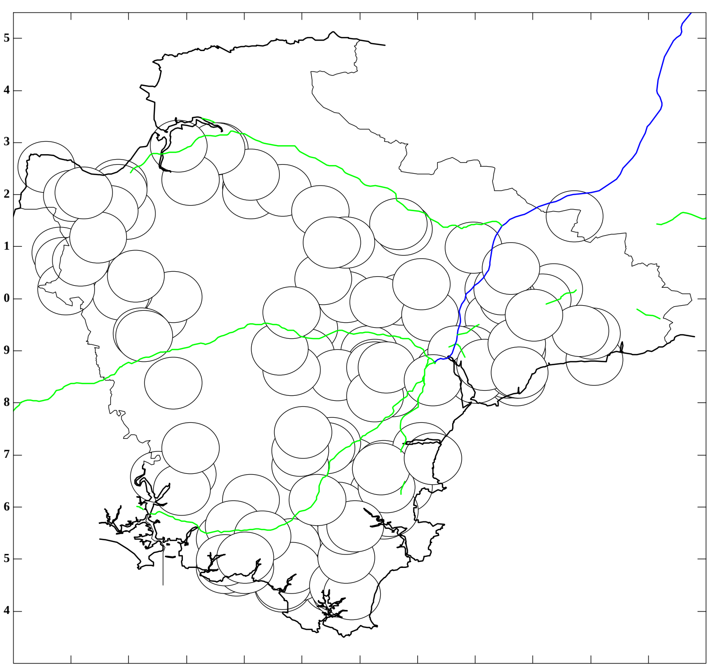
For each site, the proportion of birds ringed that were subsequently reported as major road casualties was calculated and the total length of modern A roads, dual carriageways and motorways within a 10 km radius was measured. This radius was chosen because it contained most of the median dispersal distance of 11.3 km (see 5.4). Road lengths were measured on 1:151000 Ordnance Survey maps using a wheel map-measurer. Major road length was plotted (Fig. 7.1) against proportions of those ringed that were reported as major road casualties at each site.

7.5 Results

Map 7.1 shows the distribution of the ringing sites in relation to the network of major roads in the county. The distances between each ringing site and the nearest major road varied between 400 metres and 22.5 km, which is close to the maximum attainable distance in the county. Thus, the amount of major road within 10 km of each ringing site showed considerable variance.



Map 7.1 The distribution of Barn Owl ringing sites and major roads in Devon.
Only those sites where the ringing total is known are shown (n=128).



Map 7.2 *The distribution of road length measurement areas (10 km radius around each Barn Owl ringing site) and major roads in Devon.*

Map 7.2 shows the distribution of ringing sites and illustrates the variation in the amount of major road within each 10 km radius area. Many of these areas contained no major road and, of those that did, none were surrounded by major road.

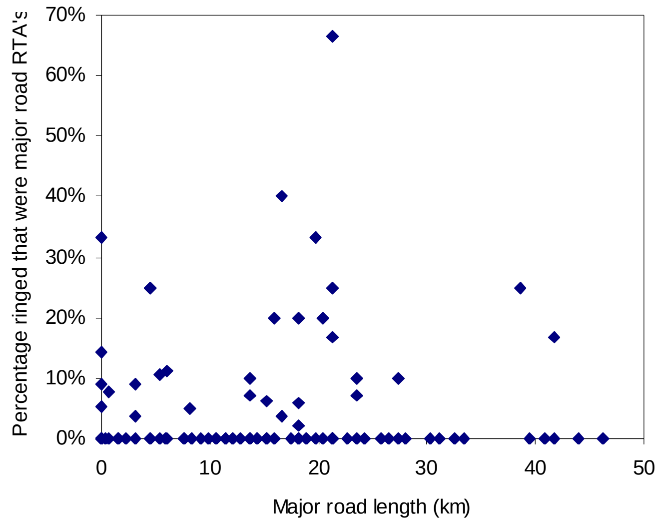


Figure 7.1 *Relationship between the percentage of birds ringed at a ringing site that were recovered as major road casualties and major road length within a 10 km radius (314 km^2) around that site.*

The data of Fig 7.1 were not significantly correlated (r_s = 0.06, P = 0.48). Many of the ringing sites produced no major road casualties. A similar statistical analysis was conducted on a reduced data set in which all ringing sites that did not produce any recorded major road casualties were excluded (Fig 7.2) (n=95). A positive correlation was found, but it was not statistically significant (r_s = 0.2, P = 0.26).

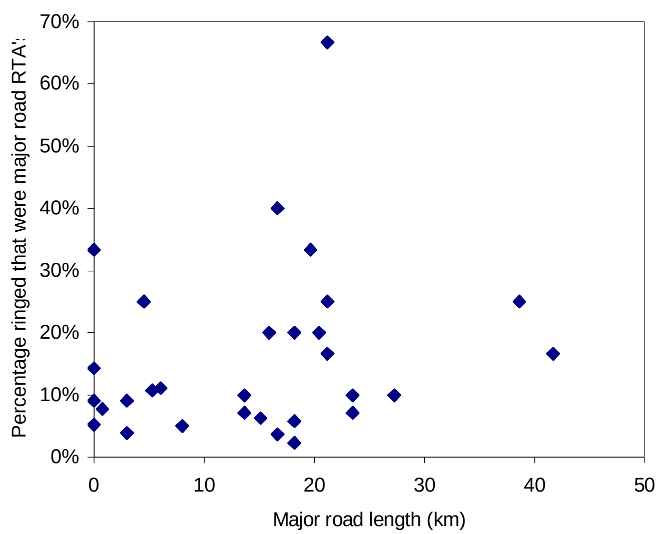


Figure 7.2 *Relationship between the percentage of birds ringed at a ringing site that were recovered as major road casualties and major road length around that site, but excluding those ringing sites from which no major road casualties were recorded.*

The recovery distance was examined for each major road casualty that came from a site that had a length of major road within 10 km. Out of a total of 57 ringed pulli which subsequently died on such a road, the majority (38) died on one which was not the nearest to their natal site. Only 18 died within the 10 km radius area within which major road length was measured and there was also one bird who's recovery place was unknown.

7.6 Discussion

Measuring the amount of major road close to a site (in this case length within a 10 km radius) is a simple process. If the relative safety of any given site were directly proportional to such a measure, conser vation effort could easily be targeted to minimise the risk to dispersing pulli. However, it is evident that whilst there was a positive relationship, it did not explain the variance between sites in recorded major road mortality rates.

Most of the ten kilometre radius circles contained no major road and of those that did the road normally passed through only one side of the circle. It is therefore probable that the majority of dispersing young were not encountering a major road within 10 km of the nest.

Considering those birds that were reported as major road casualties, most did not die within a 10 km radius, the area where major road length was measured. It is therefore probable that most of the birds destined to become major road casualties happened to disperse in a direction in which there was no major road within 10 km.

A problem with this method of quantifying major road is that it took no account of direction. If birds dispersed in an ever-increasing circle (an outward spiral flight path), or, if the major roads had been so densely distributed that they occurred within 10 km in all possible dispersal directions, the correlation may have been significant.

The weakness of the correlation suggests that a different method of quantifying the presence of major roads is needed. As so many of the Barn Owl major road casualties had dispersed beyond the species overall median dispersal distance, the presence of major roads at greater distances needs to be considered.

Dispersal direction is random and disp ersal distance highly variable, therefore a method that quantifies the distance to the nearest major road in all directions simultaneously may be more appropriate (see Chapter 10).

Chapter 8 – Barn Owl Dispersal and Mortality and Road Type

8.1 Summary

Using BTO ring-recovery data, the post-fledging dispersal of Barn Owls ringed as nestlings in Devon was investigated in detail. The pattern of dispersal was examined in terms of distance moved, timing of movement, duration and finding circumstance. Recoveries were divided into non-road (mainly starved, drowned, or flew into wires), minor road (country lanes and traditional A and B roads combined) and major roads (motorways, dual carriageways and modern A roads). The dispersal patterns of birds in each recovery class were compared in order to investigate the relative importance of major roads as a cause of both juvenile and adult mortality.

Non-road deaths and minor road deaths were numerous in the early stages of dispersal and within a relatively short distance of the ringing sites. Such deaths decreased with both time and distance, which suggests that the survivors may have learned to avoid frequently encountered hazards, such as lack of food, water tanks, overhead wires and minor road traffic.

Major road deaths, however, increased with both time and distance. Birds could obviously only be killed on major roads which they actually reached and, in the process of reaching them, young Barn Owls faced many hazards and most starved, drowned, flew into wires, or became minor road casualties. The Barn Owls that reached major roads were those that had survived exposure to these other hazards. It is suggested that most birds killed on major roads are not those that would have died anyway. Rather, major roads primarily kill older birds that should have survived.

8.2 Background

Information on the distances moved by individual Barn Owls is mainly derived from ringing and recovery data and can be used as a measure of dispersal (Percival 1992). The general pattern for the species involves a post-fledging dispersal, which commences when the young are around three months old and generally stops by the end of November, when most juveniles are around six months old. Once established, adult Barn Owls are highly sedentary and do not normally leave their home range, which in winter can extend to 5 km from their former nest site (Bunn *et al*. 1982; Taylor 1994; Wernham *et al*. 2002).

Although a small minority of Barn Owls move great distances, the greater proportion moves less than 10 km (Bunn *et al*. 1982). Using ringed nestlings recovered within 150 days (n=384), Wernham *et al*. (2002) showed that the median juvenile dispersal distance was 12 km. The median natal dispersal distance from birth site to nest site was also 12 km. The same study confirmed the highly sedentary nature of adults, giving a median breeding dispersal distance of 3 km. It should be noted, however, that these datasets included birds from all recovery circumstances, including roads and are subject to the biases discussed in Chapter 1.

Data from sources other than ring-recovery and therefore not subject to the same biases, confirms the general pattern. In southwest Scotland, information on natal dispersal was gathered by re-trapping nesting adults (n=83), which had been ringed as nestlings. 78% had moved less than 10 km, 17% 10-15 km and less than 5% had moved more than 15 km (Taylor 1994). In his "found-by-general-search" assessment of mortality (see A1.3), Taylor (1994) confirmed that adults do not generally venture outside their home range; 73% of those found were less than 3 km from their former nests and 100% (n=54) were *"within their normal winter range."*

Little is known about the post-fledging dispersal flight-paths of Barn Owls. The only radio-tracking study of Barn Owl post-fledging dispersal was carried out on Anglesey (Seel *et al.* 1983). This tracked the dispersal of birds (n=9) by identifying their daytime roost sites over a 28-week period. No attempt was made to investigate the birds' foraging movements. The earliest recorded movement of a Barn Owl was in the 10^{th} week after hatching. By 15 weeks old (5-6 weeks post fledging), all birds had roosted away from the nest at least once. Three of the nine returned to the nest to roost after having roosted elsewhere, one in its 10^{th} week, one in its 12^{th} week and one in its 17^{th} week. Radio contact with most birds was lost by the 17^{th} week. One starved, one drowned, one died of unknown cause and the remainder either disappeared or their radio transmitter became detached. However, several birds were tracked successfully and the relative position of their various roost sites suggested that dispersal (< week 28) consisted mainly of a series of relatively brief one-way movements between roost sites, or clusters of sites, that were occupied for between 3 and 15 weeks. Percival (1990) stated that distance moved between ringing and recovery can be used as a measure of dispersal. However dispersal should perhaps be considered as a series of shorter movements between several trial sites where young birds attempt to establish themselves with some directional changes en route.

The distances moved by birds in dispersal may be related to population density. For example, a juvenile bird that fails to find a vacant territory, as a result of high population density and territoriality, may be forced to travel further and may therefore encounter more hazards. In this situation, far-moving birds may be an indication of a healthy population and therefore their loss deemed relatively unimportant. However, in Devon, Barn Owl population density is generally very low. Estimates range from 3.5 pairs per 10 km sq (Shawyer 1987) and 4.4 pairs per 10 km sq (Grant *et al.* 1994), to 3.6 pairs per 10 km sq (Toms *et al.* 2000). In addition, Barn Owls do not defend their foraging ranges (Bunn *et al.* 1982; Taylor 1994). Therefore the distances moved by Devonian Barn Owls are more likely to be related to the poor quality of habitat (Ramsden 1995) rather than to population density.

Some authors have suggested that the high numbers of juveniles killed on roads in their first autumn or winter may not be important. For example, Shawyer & Dixon (1999) suggested that the loss of juvenile birds resulting from road mortality may not have contributed to overall long-term population decline because a proportion of these birds were likely to succumb to other mortality causes. Taylor (1994) suggested that, in many cases, road collisions were the proximate, rather than the ultimate, cause of death. Shawyer (1987) suggested that it was debatable whether or not road mortality was contributing to an increase in mortality or simply replacing more natural causes. However, suggestions that most birds involved in road collisions were going to die anyway are not based on research.

Very few studies have separated recoveries according to finding circumstance and compared the timing and distance of road recoveries with non-road recoveries. Taylor (1994) did consider the distance moved by road casualties, for the purpose of demonstrating the possible influence of the accidental transportation of carcasses (see A1.11), but used a sample of only 23 birds and the results were inconclusive (Taylor 1994). Percival (1990) found a strong correlation between first-year dispersal distance and finding circumstance (on roads) and seems to have assumed that this was simply a result of accidental transportation.

To date, a lack of research into the movement and longevity of Barn Owls in relation to finding circumstances, has prevented an assessment of the relative importance of various mortality causes.

8.3 Aims

1) To investigate the age of birds in relation to their finding circumstances and road type (in the case of road casualties).

2) To investigate the distance moved by first year birds in relation to their finding circumstances and road type (in the case of road casualties).

3) To investigate the relationship between distance and duration for all recoveries and then for major road, minor road and non-road recoveries.

4) To describe the dispersal pattern, the influence of different mortality causes and the relative importance of major road deaths.

8.4 Methodology

Barn Owls ringed as pulli were selected from the available ring-recovery data. Within the reported recoveries of these birds, all those that failed to fledge were excluded. This produced a sample of 166 Barn Owl recoveries, 56 of these were of unknown finding circumstance and 4 of unknown road type.

The recoveries of birds of known finding circumstance were divided into major road casualties, minor road casualties and those that died of other causes. The accumulation of recoveries through time, for each recovery class was investigated along with the number of recoveries of birds within various distance bands in each recovery class.

The distances moved were then plotted against duration to see if birds that dispersed further, perhaps because they were failing to establish themselves, died more rapidly than birds that moved shorter distances. The recoveries were again divided into the three groups (non-road, minor road and major road) and distance was then plotted against duration for each group.

8.5 Results

8.5.1 Durations

The following two graphs depict the accumulation through time of reported recoveries of first-year birds. It is important to note that each one uses different data sampling and depicts different time periods which include all or most of the post-fledging dispersal period, normally complete by circa 180 days (see Chapter 5, Table 5.2).

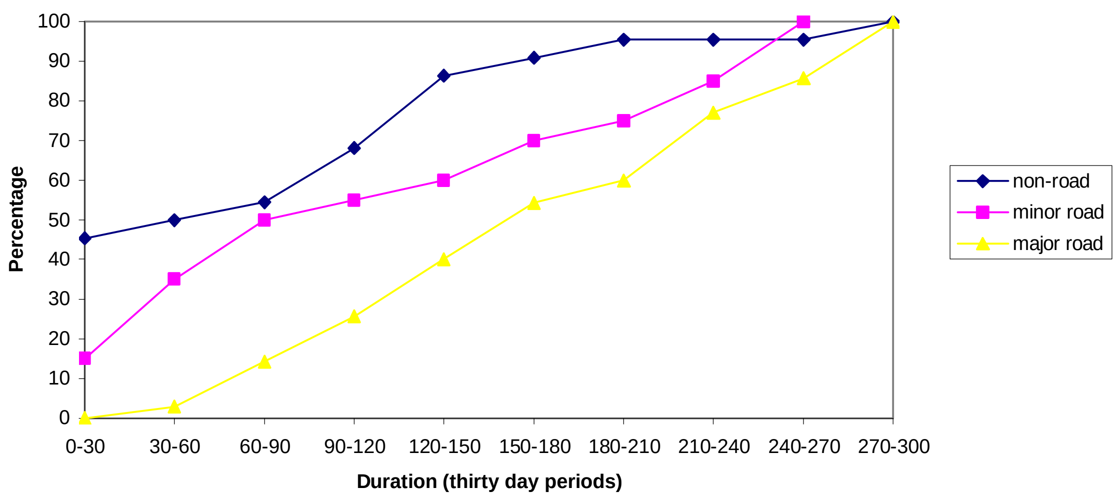


Figure 8.1 *The accumulation of Barn Owl recoveries through time expressed as a percentage of all reported recoveries in each of three recovery classes of birds found within 300 days of ringing.*

Figure 8.1 shows that 45% of all known-circumstance non-road recoveries, recorded in the first 300 days following ringing, occurred within the first thirty days, in spite of the fact that those which failed to fledge had been excluded. An investigation of the reported finding circumstances revealed that these early casualties were mainly birds that starved, drowned, or flew into wire. Considering minor road casualties, 15% occurred within the first 30 days and by day 90, 50% had already occurred. Throughout the first 300 days it is evident that major road fatalities occurred later than other types.

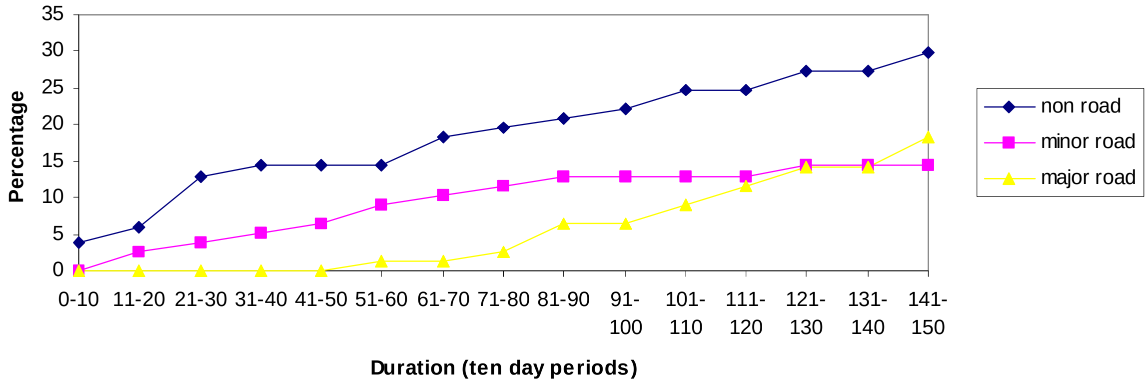


Figure 8.2 *The accumulation of Barn Owl recoveries in the first 150 days after ringing expressed as a percentage of all reported recoveries (unlimited duration) in three re covery classes (n=77).*

Figure 8.2 examines the first 150 days in more detail and shows that in the first 50 days, almost 21% of all the recoveries that were ever recorded (unlimited duration) had already occurred and that none of these were major road casualties. The first reported major road casualty was not picked up until 57days after ringing. Major road casualty numbers rose very slowly up to 80 days and then became more frequent. Conversely, minor road casualties were uncommon after 90 days.

It is evident from Figs. 8.1 and 8.2 that most reported early fatalities are of non-road casualties. Overall, reported deaths through non-road causes such as starvation, drowning, flying into wires, etc. were by far the most numerous in the early days, but decreased to such an extent that only one such recovery occurred in the final thirty day period (figure 8.1). Minor road casualties were more common during the early days post fledging and the reverse was true of major road casualties. Birds that were recorded as major road casualties had lived longer than most of those that died of other causes.

Looking at a longer-term analysis (figure 8.3) it is evident that in the second six-month period following ringing, major roads continued to account for a relatively high number of reported casualties. The low number of all recoveries in the second year and beyond may result from the fact that most birds died in their first year. Although the sample sizes were inevitably small, the data suggest that there is little difference in the relative importance of the three recovery classes amongst second-year and older birds.

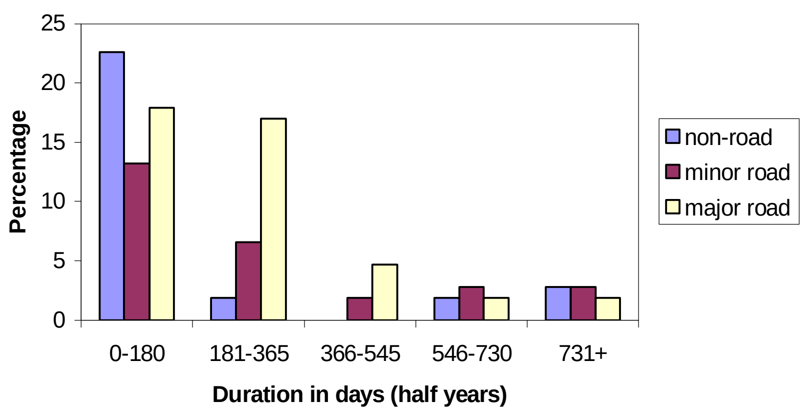


Figure 8.3 *Percentage recoveries (n = 106) reported in each half-year after ringing, divided into three classes according to finding circumstances. Based on 166 recoveries of Devonian Barn Owls ringed as pulli, excluding all recoveries where the finding circumstances or road type was unknown.*

8.5.2 Distance

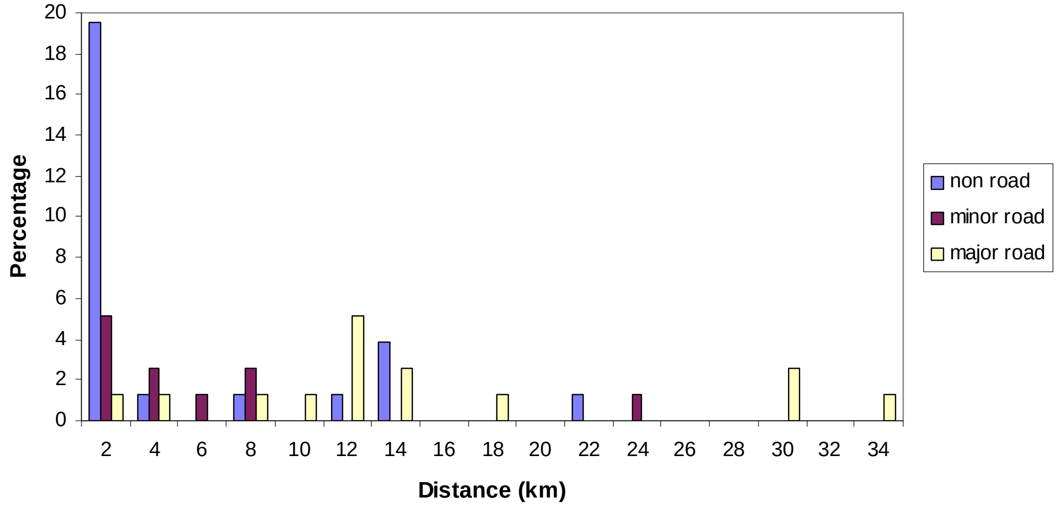


Figure 8.4 *The dispersal distances of Devonian Barn Owls ringed as pulli and recovered within 150 days expressed as a percentage of all reported recoveries within this time period (n=77), excluding those where the finding circumstances or road type was not reported.*

Well over half of all Barn Owls reported as non-road casualties within 150 days of ringing were recovered less than 2 km from their natal site. Figure 8.4 shows that those birds that survived to disperse beyond 14 km were the least likely to be reported as non-road casualties. Similarly, those birds reported as minor road casualties were almost all recovered within a relatively short distance (< 8 km). However, within 10 km of their natal sites, the birds were less likely to be reported as major road casualties. Between 10 and 14 km from the nest, juvenile Barn Owls were increasingly reported as major road casualties and again at 28 to 34 km.

Figure 8.5 shows a similar pattern but with a greater sample size which includes all Barn Owls ringed as pulli, irrespective of duration. At distances of up to 5 km, reported minor road casualties outnumbered major road casualties by two to one and non-road casualties were even more frequent. In the 6 to 10 km distance band the situation is reversed and major road casualties were the most numer ous. In the 16 to 20 km band almost all reports were of major road casualties.

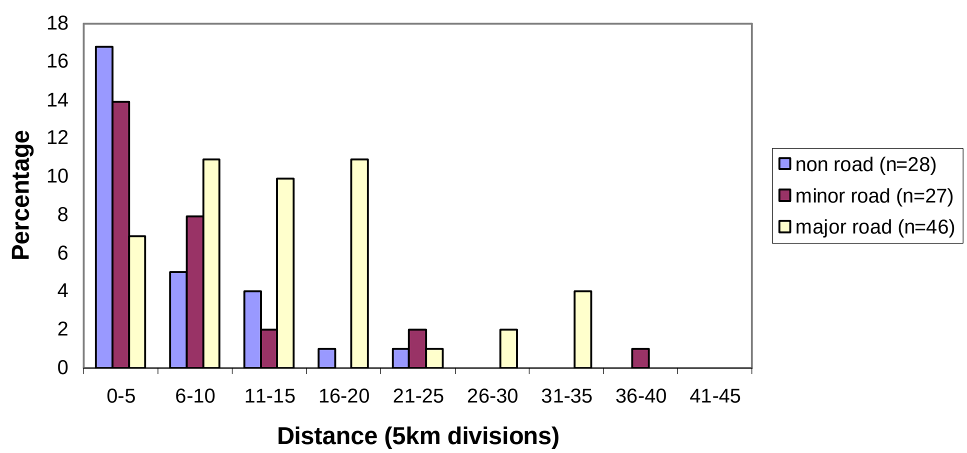


Figure 8.5 *The dispersal distances of reported recoveries of Devonian Barn Owls ringed as pulli (unlimited duration) (n=101) divided into three cl asses according to finding circumstances. Birds recovered at over 45 km distance were excluded.*

8.5.3 The relationship between distance and duration

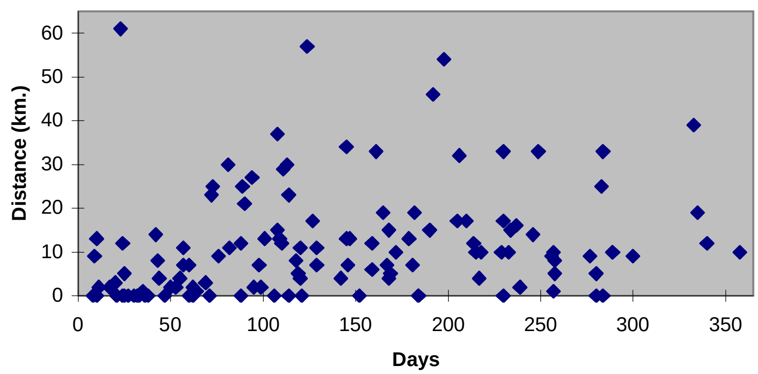


Figure 8.6 *Scatter plot of recovery distance against duration of Barn Owls ringed as pulli in the county of Devon and recovered within a year of ringing (n=131) (all finding circumstances combined, including unknown). Birds that failed to fledge were excluded.*

Most Barn Owls were ringed in June or July (see Chapter 4) and left their natal area around August. The dispersal is normally completed by 150 days after ringing (late November). Figure 8.6 shows that numerous recoveries were reported in the dispersal period (<150 days) and that almost none of those recovered within 70 days had moved more than 15 km. The recovery of one bird at a distance of 61 km only 23 days after ringing was exceptional and this might have been a case of accidental transportation (see A1.11). The maximum recovery distances within 110 days (excluding this one bird) are 14 km in 42 days, 23 km in 72 days, 25 km in 73 days, 30 km in 81 days and 37 km in 108 days. These figures suggest a maximum mean dispersal of 0.34 km/day.

Figure 8.6 also shows that during the latter part of the dispersal period (70 – 150 days), recoveries were numerous within a wide distance band but the majority of recorded deaths were still within 0 to 15 km of the natal site. In the period 150 to 300 days, which equates to the birds first winter, recoveries were more evenly distributed in both time and distance and the majority of reported deaths occurred within 20 km.

Table 8.1 and Figure 8.7 show the same recoveries divided according to finding circumstances and road type. Non-road casualty birds that were recorded as having starved, drowned, or flown into wire were mainly found within the first two-thirds of the post-fledging dispersal period at relatively short distances from their natal sites. Minor road casualties showed a similar pattern but tended, on average, to survive slightly longer and travel slightly further. However, major road casualties survived the longest and moved furthest.

	Non-road (n=29)	**Minor road** (n=26)	**Major road** (n=46)
% recovered within 5 km mean duration of these	59% 58 days	54% 184 days	15% 513 days
% recovered within 100 days mean distance of these	59% 2.6 km	38% 5.5 km	11% 14.6 km

Table 8.1 *The duration of Barn Owls ringed as pulli in the county of Devon, recovered within 5 km and divided into three recovery classes and the distance moved by Barn Owls recovered within 100 days. Excluding birds which failed to fledge or were recovered at over 45 km distance. (n=101).*

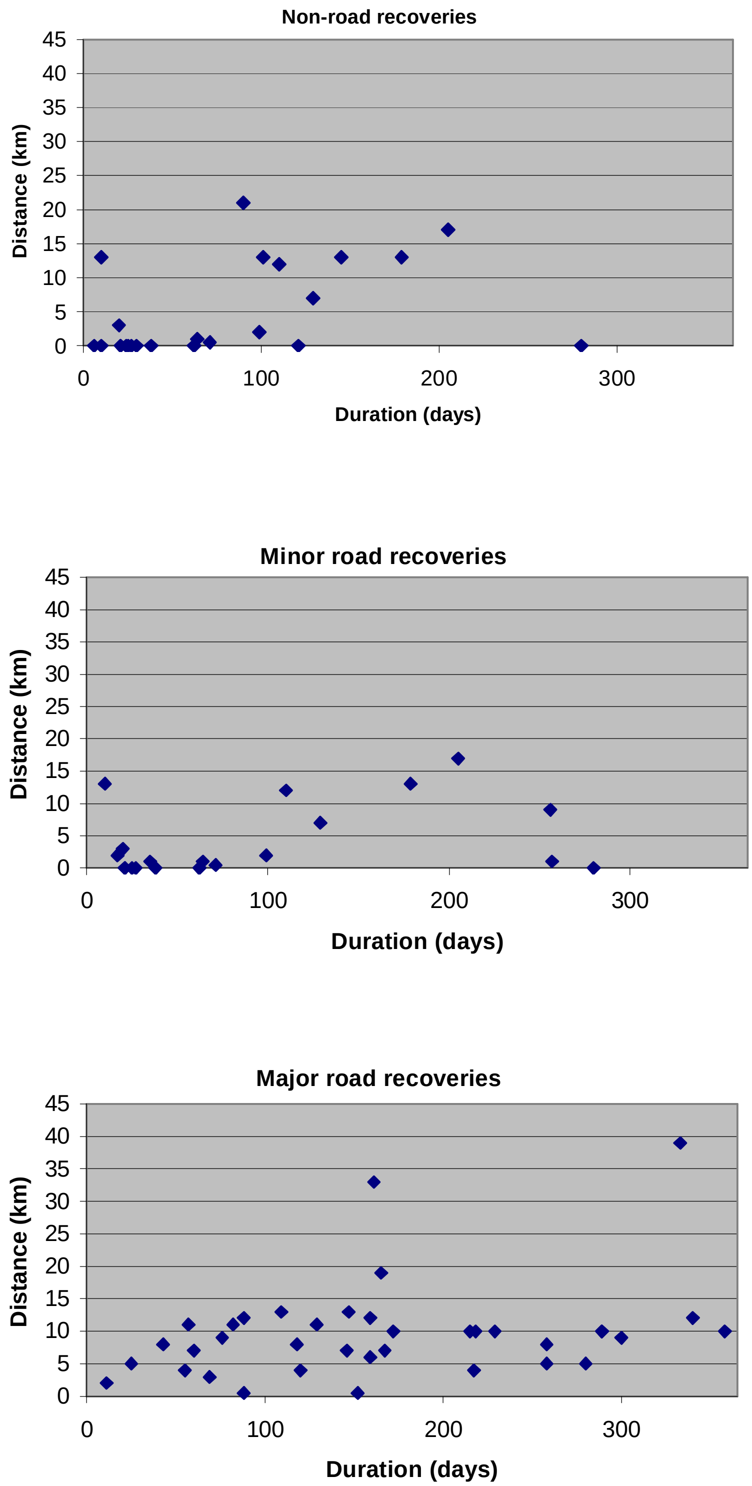


Figure 8.7 *Scatter plots of recovery distance versus time before recovery of Barn Owls ringed as pulli in the county of Devon, divided into three classes according to type of place where birds were found. Pulli which failed to fledge, or were recovered at distances >45 km, or recovered >365 day s after ringing, are excluded.*

8.5.4 Running commentary - "<u>The Brood of 101</u>"

A chronological interpretation of the dispersal pattern of an imaginary "brood" of 101 Barn Owls based on what actually happened to 101 real birds that fledged successfully and were subsequently recovered is herewith presented.

Day 6 to day 30 (summer)
Most of the 101 fledge in this first 30day period. After only six days one drowns just near the nest site (6d/<1km). Another one leaves almost immediately and is found many kilome tres away starved to death (10d/13km). Another starves too (20d/3km). Two die from flying into wires just near the nest (10d/<1km, 21d<1km). Two more drown just near the nest (24d/<1km, 30d/<1km) and one chokes on a sharp bone (21d/<1km). Three are killed on local minor roads (11d/2km, 17d/2km, 25d/5km). One is killed by a predator (25d/<1km) and another accidentally trapped in a building (27d/<1 km). The rest are still really inexperienced, only just beginning to be independent and most have not started to disperse yet.
88 are still alive.

Day 31 to day 60 (late summer)
Four more are killed on minor roads and three of these had started to disperse and must have crossed lots of country lanes before they were hit (35d/1km, 43d/8 km, 55d/4 km, 60d/7km). One is killed by a predator close to the nest site (38d/<1km). One must have dispersed soon after it fledged because it went quite a long way (57d/11km) and was the first to be killed on a major road. By now all 101 have fledged, some are still inexperienced but many are now independent and in dispersal.
82 are still alive.

Day 61 to day 90 (early autumn)
Surprisingly, four birds are still less than a kilometre from the nest; two fly into wires (62d/<1km, 62d/<1km); one starves (71d/<1km) and one dies on a min or road (88d/<1km). One dies on a railway line quite close to the nest site (64d/1km). There are two more minor road casualties, one was only a few kilometres from the nest (69d/3 km) but the other one had dispersed a really long way and must have successfully crossed lots of minor roads before being killed on one (72d/23km). Another turns up drowned in a cattle trough after dispersing a similar distance (90d/21km). Four birds that managed to avoid flying into wires, drowning, or being hit during numerous m inor road crossings, are killed on major roads (76d/9km, 81d/30km, 82d/1 km, 88d/12km). By now all 101 birds are almost certainly independent and most have dispersed away from the nest but by day 90, 31 are already dead.
70 are still alive.

Day 91 to day 120 (autumn)
Two birds are still fairly close to the nest even a couple of months after fledging. One is accidentally trapped in a building (99d/2km) and the other dies on a major road that was unusually close to the nest (106d/<1km). Two die on minor road s (118d/8km, 110d/12km) and the rest are all major road casualties (109d/13km, 113d/30km, 120d/4km). We are now well over half way through the dispersal period.
62 are still alive.

Day 121 to day 150 (late autumn)
We are now running up towards the end of the dispersal period and very few birds are left near the nest. One is drowned in the nest area (121d/<1km) in spite of the fact it has avoided drowning around here for several months. Another drowns a long way away (145d/13 km) and one flies into wire (12 9d/7km). Five birds that managed to avoid starvation, drowning and flying into wires, become major road casualties (127d/17km, 129d/11km, 145d/34km, 146d/7km, 147d/13km).
54 are still alive.

Day 151 to day 180 (early winter)
The dispersal phase is drawing to a close and some birds have already adopted a more sedentary life style. Amazingly, one bird is still around the nest (!) and becomes a minor road casualty (152d/<1km). Another becomes a minor road casualty (167d/7km) and one starves (179d/13km). Five more birds become major road casualties (159d/6km, 159d/12km, 161d/33km, 165d/19km, 172d/10km). More than half of the "brood" of 101 are now dead.
46 are still alive.

Day 181 to day 270 (mid winter and early spring)
During this longer (90 day) period the birds are generally sedentary but may forage up to 5 km from their main roost, trying to get through their first winter. One is shot (205d/17km); five become minor road casualties (217d/4km, 218d/10km, 256d/9km, 257d/1km, 258d/5km) and ten die on major roads (190/15km, 210d/17km, 215d/10km, 229d/10km, 230d/17km, 230d/33km, 237d/16km, 246d/14km, 249d/33km, 258d/8km).
30 are still alive.

Day 271 to day 365 (mid spring and early summer)
In this 90day period most of the birds have probably found a mate and their foraging range contracts as nesting gets underway and prey numbers start to increase. Amazingly, one bird is still at its natal site (!) but even so, it starves (280d/<1km). Unluckily, many choose home ranges too close to major roads; seven die on major roads (280d/5km, 283d/25km, 289d/10km, 289d/10km, 300d/9km, 340d/12km, 358d/10km) and one on a minor road (333d/39km). Out of the brood of 101, eighty have died before their first "birthday".
21 are still alive and move into their second year, experienced survivors and "valuable" birds.

Day 366 to 730 (their second year)
Once nesting is over, their foraging range increases once more with the usual result. Major roads claim another seven victims (396d/20 km, 430d/4km, 433d/18km, 450d/17km, 551d/18km , 583d/19km, 724d/4km); four die on minor roads (475d/12km, 483d/1km, 567d/8km, 645d/21km); one starves (590d/8km) and one flies into wire (625d/6km).
8 are still alive and move into their third year, highly experienced survivors and very "valuable" birds.

Day 731 to day 1095 (their third year)
In spite of their extensive experience, third year birds fall victim to the same fates as the rest of the "brood".Two die on major roads (767d/3km, 1015d/17km), two on minor roads (819d/5km, 974d/9km) and one flies into wire (1072d/8km).
3 are still alive and they become the veterans, moving into their fourth year.

Day 1096 and beyond
Interestingly the last three birds are all found relatively short distances from "the site" where "the brood" originally hatched. One died soon after its third "birthday" on a major road (3 km), one was predated just after its fifth "birthday" (7 km) and the last one died on a minor road aged six (2 km).

8.6 Discussion

8.6.1 Duration

In BTO ring-recoveries, duration is counted from the ringing date. Barn Owl pulli are normally ringed between four and eight weeks old (the average is six weeks), just before fledging (see Chapter 4). Therefore most ringed birds fledge around twenty days after ringing. Birds which were reported as found at the nest site, or very close, still with some nestling "down" were considered to have failed to fledge and were excluded from the data. Therefore, all of the recoveries used in this analysis are of birds that died, or were found injured, after fledging.

Mean duration of recovery varied considerably between recovery classes. The first major road casualty was not found until 57 days after ringing by which time half of all reported non-road deaths and half of all reported minor road deaths had already occurred. There were few minor road deaths after 90 days and after dispersal, at around 150 days, there were few non-road deaths. Conversely, major road deaths were not frequent until 80+ days. They were increasingly frequent throughout the remainder of the dispersal period (80 – 150 days) and remained frequent during the birds' first winter (150 – 300 days).

8.6.2 Distance

As with duration, there was considerable variation in distance travelled before recovery according to recovery class. Most birds in the post fledging dispersal period (0 – 150 days) were injured and/or died from non-road causes and were found within 2 km of the nest. Non-road deaths were occasional between 2 and 14 km and rarely occurred beyond this distance. The majority of minor road casualties were reported within 8 km of their ringing site. Conversely, major road deaths did not become frequent until birds were at least 10 km from their natal sites*. The results suggest that as the birds' dispersal distance increased, the chances of them becoming non-road or minor road victims decreased and their chances of becoming major road victims increased. To an extent, this is simply a reflection of the density of the different road types, although a learning process may be involved.

* NB Some major road casualties may have been accidentally transported (see A1.11). However, this is not likely to have been a major factor (see 6.6.2 f).

8.6.3 Duration and distance

In the early stages of dispersal (<70 days), deaths were recorded most frequently within 5 km and in the remaining part of the dispersal period (70-150 days), recoveries were fairly well distributed across a 0-30 km distance band. During the first-winter period (approx 150-250 days) Barn Owl recoveries were still fairly well distributed across a wide distance band. Within first-year recoveries there was no evidence that birds that moved shorter distances survived longer.

The recoveries of second year and third year birds were also well distributed across a wide distance band, however the three oldest birds had moved only 2-7 km (see 8.5.4). An analysis of distances moved by birds recovered at over two years of age, using a large national dataset, would be of interest. Overall, there was no evidence that birds that moved shorter distances lived longer.

8.6.4 The pattern of Barn Owl dispersal

Little is known about dispersal flight-paths and the only radio tracking study suggested that dispersal consists mainly of a series of relatively brief one-way movements to new roost sites, or clusters of sites, with each site usually occupied for several weeks or months before dispersal to a new site (Seel *et al.* 1983). Even at the maximum dispersal rate of 0.34 km/day (see 8.5.3), the birds have ample time to meander around, trying various roost sites and foraging areas before they die or settle in a permanent home range.

The recoveries of dead and injured ringed Barn Owls provided information about the dispersal of those birds that did not survive. This pattern was also representative of those birds that did survive the dispersal process (longer duration recoveries), but the probable biases in recovery data need to be considered. For example, starvation, flying into wires and predation were probably under-recorded compared to road casualties (see 1.3.1). Major road casualties were probably under-recorded in relation to minor road casualties (see 6.6.3). The reader should be mindful of the above limitations whilst interpreting the "brood of 101" running commentary.

From the commentary, it is evident that only 21% of Devonian Barn Owls survive their first year. Percival (1990), in his examination of the BTO national ring-recovery data, gave a similar figure of 25% first-year survival in British Barn Owls.

8.6.5 Exposure to and avoidance of hazards

The data presented suggests that the birds' vulnerability to some man-made dangers decreased with their exposure to it. However, the owls' ability to learn to recognise and/or avoid danger is unknown.

Almost all farms in Devon have overhead telephone and electricity cables, numerous water troughs and very little good Barn Owl habitat. All Devonian Barn Owls must frequently encounter these hazards, both during dispersal and within any established home range. The fact that a minority of Barn Owls are able to survive for years amongst such hazards suggests that they may learn to avoid danger rather than survive simply through luck.

Non-road recoveries of fully-fledged young birds (mostly starved, flown into wire, or drowned) mainly occurred very close to the birds' natal site within the first 70 days (fig 8.7) and may be linked to inexperience. Once birds had reached 100 days since ringing they were more experienced, but even birds that had dispersed over 10 km and must have encountered non -road dangers repeatedly, were still subject to non-road mortality, although such recoveries were relatively uncommon after the dispersal period.

Like non-road hazards, minor roads are densely distributed across Devon farmland and must be frequently encountered by all Devonian Barn Owls. During the dispersal phase (<150 days), almost all minor road recoveries occurred within the first 90 days in spite of the fact that exposure to minor roads must have been fairly constant throughout dispersal and beyond. This t oo suggests that the birds may, to some extent, have learned to avoid vehicles on minor roads, or avoid minor roads altogether, as suggested by Taylor (1994).

Compared to minor roads, there are very few major roads in Devon and therefore exposure to major roads during dispersal is far from constant. Major road recoveries were very few in the early days of dispersal and close to the nest site because in most cases there was no major road present. Owing to lack of exposure, Barn Owls have no opportunity to l earn to avoid the dangers associated with major roads, in particular the combination of rough grass verges with the greater speed and frequency of traffic. Evidence presented in Chapter 6 suggested that when a Barn Owl encounters a major road for the first time it quickly dies or otherwise disappears.

Photo: David Ramsden

8.6.6 Importance of major road deaths

Most non-road deaths occurred during the dispersal period and were within 2 km of the nest, only occasionally between 2 and 14 km and rarely occurred beyond this distance. Minor road casualties were almost all reported from within 8 km in the first 90 days of the dispersal period. This suggests that as the birds' dispersal distance and life-span increases, the chances of them becoming non-road or minor road victims decreases. If these are the only hazards the birds have to face, the evidence suggests that they would have lived on. Unfortunately, many of the initial survivors became major road casualties in the final stages of dispersal, or during their first winter.

Major roads can kill only the birds that reach them. In the process of reaching them, the birds face many hazards and most starve, drown, fly into wires, or are hit on minor roads. The birds that reach major roads are the survivors. I suggest that major roads do not mainly kill birds that would have died anyway. Major roads mainly kill birds that would have survived longer.

Chapter 9 - Major Roads as Barriers to Barn Owl Dispersal

9.1 Summary

Of the BTO ring-recovery details of Barn Owls (n=192), 94% were ringed as nestlings. Ringing sites were well distributed across the study area and many of the sites had a major road within the mean recovery distance (12 km). The ringing sites were divided into those that produced one or more recorded major road casualties and those that did not. Surprisingly, the mean distance from ringing site to the nearest major road was similar for both classes of sites; most of the major road casualties did not die on the stretch of major road that was nearest to their natal site. Some sites within half a kilometre of a major road did not produce any recorded major road casualties, whereas some sites over 15 km away did.

Most of the dispersal movements occurred in areas without major roads and it is probable that most Barn Owls did not encounter one. However, at least 62 birds must have encountered a major road and of these 72% were killed. A few birds successfully crossed a major road but about half of those that were later found dead were killed on another road. The probable biases contained in the data are considered and it is concluded that most Barn Owls encountering a major road for the first time quickly became road casualties. It is suggested that major roads act as a partial barrier to Barn Owl dispersal and may have played a significant part in Barn Owl population decline in parts of Britain.

9.2 Background

9.2.1 Roads as wildlife barriers

Roads can restrict the movements of wildlife in a variety of ways: visual and auditory disturbance may induce avoidance behaviour or mortality may prevent successful crossing (Singleton & Lehmkuhl 2000). Roads can function ecologically as partial or complete filters to animal movement and may reduce species' ability to recolonise an area should a subpopulation become extinct (Singleton & Lehmkuhl 2000). Owing to their great length, roads can also cause landscape fragmentation, but in spite of the fact that this is considered by many authors to be the most important ecological effect of roads and their traffic, there are few reports on the subject (Spellerberg 1998). The effect of roads as barriers to movement of terrestrial animals is relatively well documented (Byron *et al*. 2000). The idea that roads may act as partial barriers to birds appears not to have been investigated. Indeed, even in main reports it was hardly mentioned (see, for example, Markham 1996). In assessing the potential impact of road schemes, local wildlife population dynamics are not studied, even in the case of protected species such as the Barn Owl (Byron *et al*. 2000).

9.2.2 Roads as barriers to Barn Owls

The high incidence of Barn Owl mortality and the relative lack of live owl sightings on major roads suggests that dispersing juvenile Barn Owls which encounter major roads are either killed quickly or move on (see 6.6.5). If a high proportion is killed, then major roads may act as barriers to Barn Owl dispersal. This could have serious implications for the whole Barn Owl population by restricting juvenile dispersal and thereby partially inhibiting both the long-term continuous occupation of traditional nest sites and the occupation of new ones (see Chapter 4). To date, no research on this subject has been carried out. Do major roads kill every Barn Owl that encountered one or is there evidence to suggest that Barn Owls survive such encounters and move on?

9.2.3 Interpretation of BTO ring-recovery data

In Britain around one in seven BTO ringed Barn Owls are subsequently recovered (see A1.1) and, with the exception of one small radio-tracking study (see 8.2), ring-recovery provides the only information on dispersal of individual Barn Owls across the countryside. However, the level of detail provided by such data is limited. The majority of ringed birds were only reported once after ringing, usually dead. The resulting data usually contains only one movement and no information on the route taken from ringing place to finding place. It may be unwise to assume that any recovered bird did not move further than its ultimate recovery distance. Thus, a bird ringed at A and later found dead on a major road at B, may have moved beyond B and crossed the major road any number of times before being killed. However, this was considered unlikely because sightings of live birds from major roads were infrequent (see 6.6.5). Also, that dispersal recovery distance increases with age (Wernham *et al.* 2002) suggests that birds do not repeatedly reverse their dispersal direction. However, in using ringing and recovery data vis à vis birds encountering and/or crossing roads, it is important to consider the dispersal behaviour of Barn Owls.

9.2.4 Barn Owl dispersal flight paths

The only information on Barn Owl dispersal flight-paths comes from the Anglesey radio-tracking study (see 8.2) which suggested that dispersal consisted mainly of a series of relatively brief one-way movements between roost sites, or clusters of sites, that were occupied for several weeks or months. It may be reasonable to assume that young birds used these sites as temporary bases from which they made nightly foraging sorties. If they had difficulty finding food, were unduly disturbed, or discovered a better area by chance, they moved on. In their movements between daytime roosts, only two of the Anglesey birds were tracked more than seven weeks after fledging and beyond 1 km from the nest. One of these birds was tracked for fourteen weeks. It stayed within 300m of the nest for 6 weeks then over the next 8 weeks used seven different temporary roosts on its dispersal path prior to loss of radio contact. Most of its movements were away from the nest and only one was back towards it. The second owl was tracked for eighteen weeks after fledging. It left the nest site after only two weeks and moved 1.5 km within a week and roosted in the same area using a small cluster of five different sites for a 15-week period before radio contact was lost. The dispersal flight paths of all birds that were radio-tracked were always in one direction away from the nest, ie. there were no birds that returned and dispersed again in a different direction and there were no birds that dispersed in an ever-increasing circle (Seel *et al.* 1983).

It has been suggested that Barn Owls disperse along linear habitat features, such as waterways with rough grass banks (Shawyer & Dixon 1999) but there is no evidence to support this view. In Devon the only significant linear habitat features are hedgerows and major road verges. If dispersing juveniles did follow hedges this would have little or no influence on dispersal route, as hedges are so numerous and well distributed in all directions. Evidence presented elsewhere in this report suggests that major roads are not used as dispersal corridors (see 6.6.5).

9.3 Aims

1) To investigate whether the spatial distribution of major roads in relation to nest sites is likely to produce birds that are naturally inclined to disperse across major roads.

2) To determine from where the reported ringed casualties found on individual major roads have come.

3) To determine what proportion of recovered birds: -

- Died on a major road which *may* have been the first one encountered
- *Must* have survived a major road crossing

4) To investigate what subsequently happened to such survivors.

5) To investigate the extent to which major roads might act as barriers to dispersal.

9.4 Methodology

The ringing sites were split into two sets: those that did and those that did not produce one or more recorded major road casualties. Using Dmap, the spatial distribution of these ringing sites was visually compared to the distribution of major roads.

The dataset of ringed major road casualties was divided according to the road on which they were found. Using similar maps the ringing site and finding place were plotted with link lines.

For each individual ring-recovery the ringing and finding places were mapped by hand in order to determine if each bird:

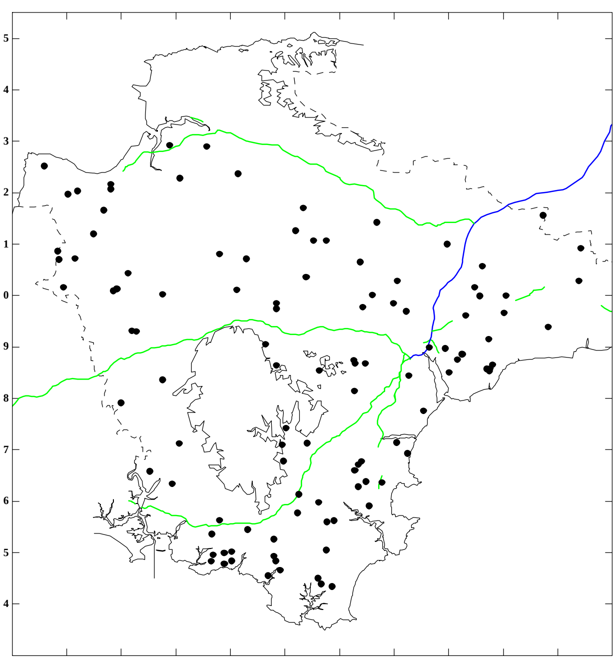
- Was killed (or injured) on what was *probably* the first major road it encountered
- *Could* have moved without encountering a major road
- *Must* have crossed one major road (once or more)
- *Probably* crossed two major roads (once or more)

Movements across major roads were plotted using link lines. Because two sections of major road were constructed during the study period, great care was taken to ensure that the major road in question actually existed at the time. There were two cases where a bird moved in a district where a road was constructed and the probable movement area and/or the movement period, straddled the construction place and date. Both birds were excluded from the data for this analysis.

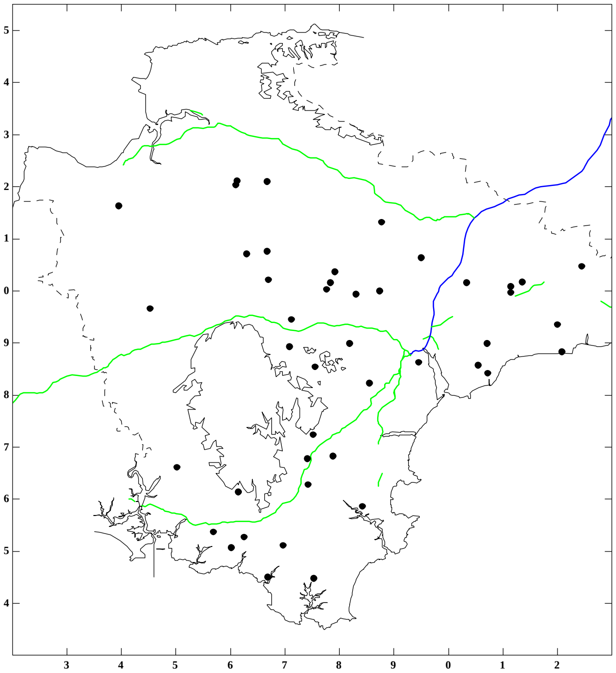
The finding circumstance of each bird that must have crossed one or more major roads was investigated.

9.5 Results

Map 9.1 shows the Barn Owl ringing sites in Devon which did not produce any recorded major road casualties (MRTAs) and Map 9.2 shows those sites which did produce one or more recorded MRTA. It was evident that both classes of ringing sites were well distributed, both throughout the county and across the major road network.



Map 9.1 *The county of Devon showing the distribution of major roads and ringing sites which did* ***not*** *produce any recorded major road casualties.*



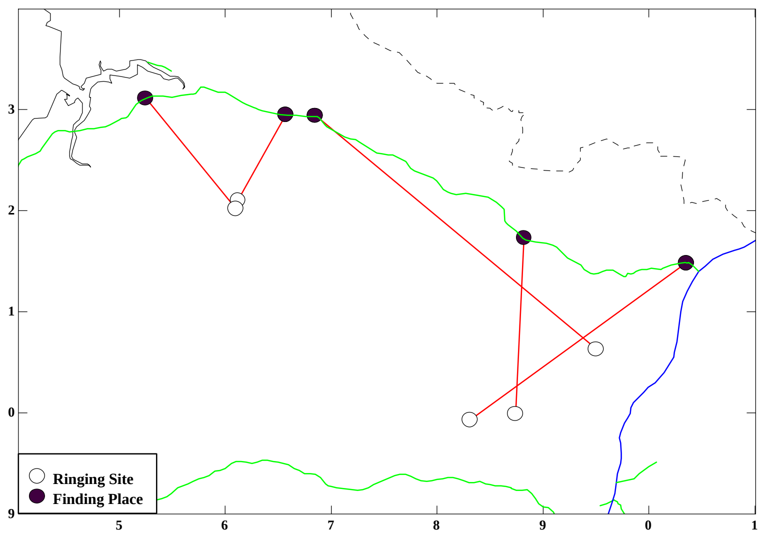
***Map 9.2** The county of Devon showing the distribution of major roads and ringing sites which produced one or more recorded major road casualties.*

There are ample examples of sites within 10 km of a major road that did not produce recorded MRTAs and an ample number of sites that did. Similarly there are numerous sites in the 10 to 20 km range which did and which did not (see table 9.1).

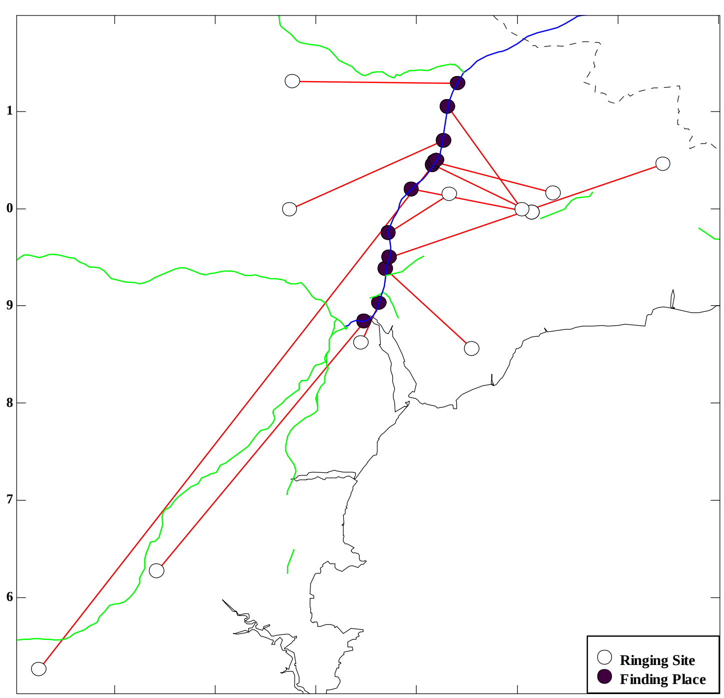
	number of sites	Distance to nearest major road range	mean
Ringing sites which **DID** produce one or more recorded major road recoveries	44	0.75 - 14.5 km	6.4 km
Ringing sites which **DID NOT** produce any recorded major road recoveries	108	0.4 - 22.5 km	7.6 km

***Table 9.1** The distance between Barn Owl Trust BTO ringing sites in Devon (divided into two classes) and the nearest major road (motorway, dual carriageway, or major 'A' road).*

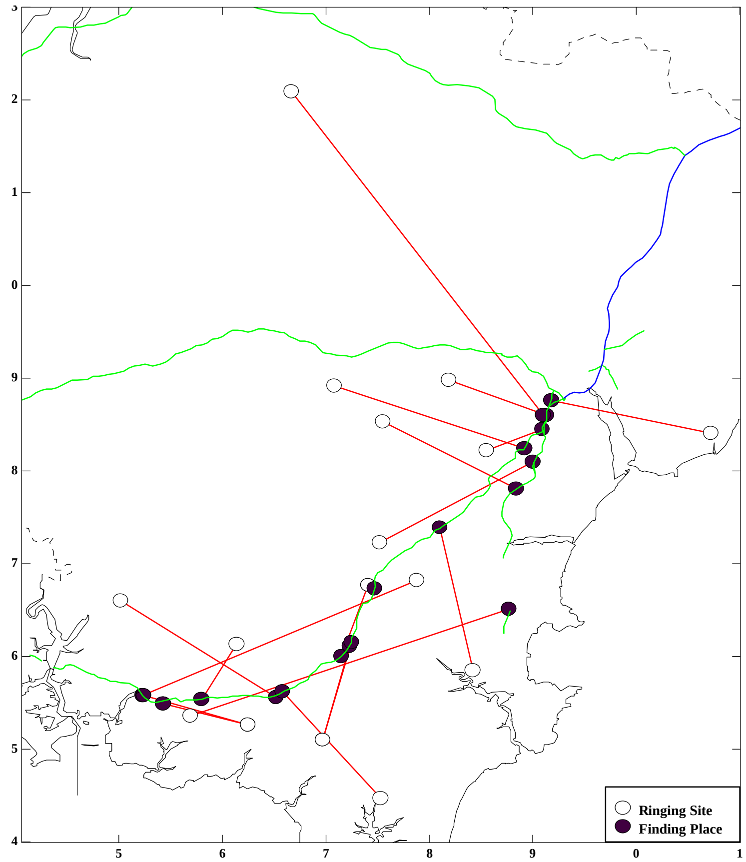
The mean major road distance values for both classes of ringing sites (6. 4 km and 7.6 km) are below the mean dispersal distance for Barn Owls (12 km). Therefore birds from both classes of sites were likely to encounter major roads.



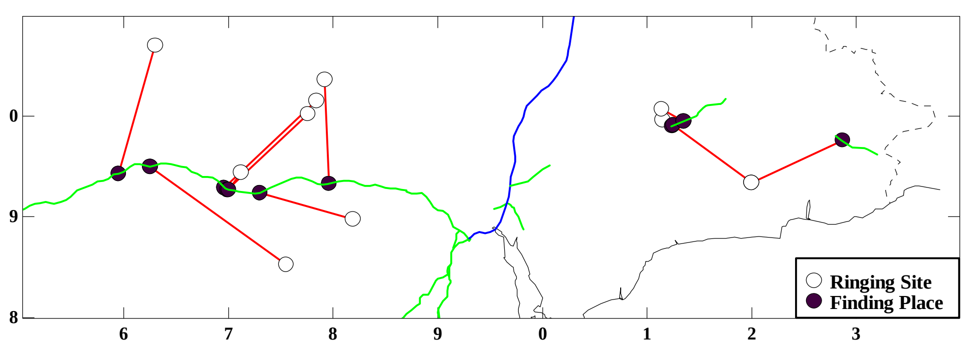
Map 9.3 *The movement of reported ringed Barn Owls which died on the A361 North Devon Link Road, from ringing site to finding place.*



Map 9.4 *The movement of reported ringed Barn Owls that died on the M5 Motorway in Devon, from ringing site to finding place*



Map 9.5 *The movement of reported ringed Barn Owls which died on the A38 (De von Expressway) and A380 Dual Carriageways, from ringing site to finding place.*



Map 9.6 *The movement of reported ringed Barn Owls which died on the A30 Dual Carriageway and A35 Axminster By-Pass, from ringing site to finding place.*
Note: A30 casualties in west Devon were excluded due to road construction part way through the period (see 9.4).

Map 9.2 shows the movement from ringing site to finding place for all five of the ringed road casualties reported from the A361 North Devon Link Road. (Note: this road was not built until 1987-89, hence the relatively low sample size). Only one of the five birds died on the nearest stretch of major road to its ringing place. Similarly maps 9.4, 9.5 and 9.6 show that most of the birds that died on a major road d id not die on the nearest stretch/nearest one. Referring back to map 9.1 and comparing the distribution of sites to maps 9.2-9.6, it is evident that ringed birds which were “destined” to become MRTAs flew past ringing sites which did not produce any record ed MRTAs on their way to their death places.

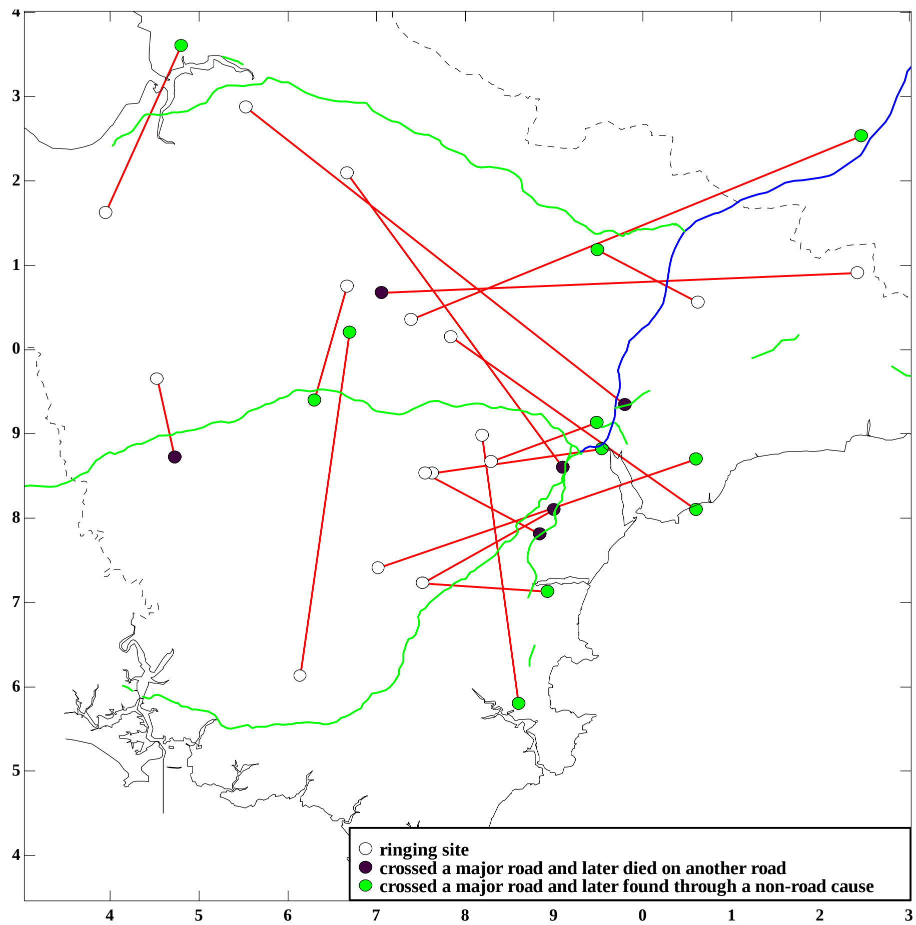
Out of a total of 1,163 ringed Barn Owls there were 255 recoveries reported of which 63 were excluded (see 5.3). The remaining 192 recoveries (all finding circumstances and including 19 controls) comprised 180 birds ringed as pulli and 12 ringed as adults. Each movement was individually examined in relation to the proximity of all major roads in the study area. Table 9.2 shows the interaction between movements and major roads. Most of the movements were of birds that probably never encountered a major road, as both the ringing and recovery sites were well away from them. However there were 62 movements of birds that must have encountered a major road. Map 9.7 shows these movements as link lines.

Circumstances	**Number**	**Percentage**
Total number of recoveries (including 19 controls) minus exclusions	192	100%
Recovered at ringing site (but fledged and survived long enough to discover roads) [duration range 6 to 1131 days]	26	13.5%
Recovered at less than 1 km from ringing site [duration range 32 to 152 days]	8	4.2%
Recovered more than 1 km from ringing site [distance range 1 to 137 km]	157	81.8%
May never have encountered a major road	130	67.7%
Definitely* did encounter a major road	62	32.3%
……….of the 62 which definitely* did encounter a major road…………...		
Total number of major road casualties	48	77.4%
Died on a major road which may have been the first one encountered	45	72.6%
Total number that must* have crossed a major road (once, or more) and survived	17	27.4%
Crossed and then died on another major road	3	4.8%
Crossed then died on a minor road	3	4.8%
Crossed then died by a non-road cause	3	4.8%
Crossed then died by an unknown cause	5	8.1%
Crossed and then controlled (alive)	3	4.8%
Must have crossed two different major roads	0	0%

Table 9.2 *The movement of BTO ringed and recovered Barn Owls in Devon in relation to the network of major roads ('A' roads, dual carriageways and motorways) in the period 1985 to 1999.*

All of the 62 Barn Owls that definitely* encountered a major road were within the 93.3% that were ringed as pulli. Those ringed as adults only moved on average 2.6 km and were therefore much less likely to encounter a major road.

*One bird appeared to have crossed the A361/A39 North Devon link road but may have flown around its western end (see map 9.7).



***Map 9.7** The movement from ringing site to finding place of all recorded Barn Owls that crossed a major 'A' road, motorway, or dual carriageway in Devon (n=17) in the period 1985 to 1999 inclusive.*

9.6 Discussion

9.6.1 Distribution of major roads in relation to nest sites

The distribution of ringing sites in relation to the network of major roads in Devon was such that numerous Barn Owls were likely to have encountered a major road in post-natal dispersal. However, most ringing locations, including some relatively close to major roads, did not produce any birds that were known to have encountered a major road. This was to be expected, since many ringing sites produced only one or two reported recoveries, dispersal direction was random (see 5.4) and the overall recovery rate is only one in seven.

9.6.2 Origins of major road casualties

Birds that became major road casualties had often come from distant ringing sites rather than those closest to the road on which they were found. Dispersing birds would only be likely to first discover the *closest* section of major road if they moved in that direction by chance, or dispersed in ever-increasing circles, which is most unlikely (see 9.2.4). Some birds that were later recovered as major road casualties must have flown past ringing sites which did not produce any recorded major road casualties. Overall, ringing sites that did not produce any recorded major road casualties were only slightly further away from major roads than those that did (see Table 9.1).

9.6.3 Major road encounters: death and survival

Although most recorded movements were well away from major roads, ring recoveries confirm ed that many birds did encounter major roads (62 out of 192 recoveries) and most of these were major road casualties (73% of 62 recoveries). The likely biases obviously need consideration.

Reported Barn Owl mortality was almost certainly biased towards ro ads, as suggested by Illner (1992) and Taylor (1994) (see 1.3.1) and therefore birds that were killed on a major road were more likely to be reported than the birds which crossed. However, there are two factors that probably counteracted this to some extent:

a) At least 18% of the birds which successfully crossed a major road were later reported elsewhere as major road casualties and were, therefore, no less likely to be reported than those birds which died during their first major road encounter.

b) Another 18% of the birds which successfully crossed a major road were later reported as minor road casualties and were therefore more likely to be reported than those birds which died during their first major road encounter (see 6.6.3).

Although unlikely (see 6.6.5), any of the birds that encountered a major road could have dispersed along it for a distance, as suggested by Shawyer & Dixon (1999) before being killed or moving on. Map 9.4 shows two movements running roughly parallel to major roads, suggesting that the birds may have used the road as a dispersal route. The most extreme example is of a bird that was ringed as a nestling only 1 km from a major road and was picked up dead 145 days later, 34 km further up the same road. However this bird may have been accidentally transported on the front of the vehicle that struck it (see A1.11), or could have flown to its finding place without encountering the road before it was killed.

Of those birds that were known to have definitely encountered a major road (T able 9.2) 72.6% were killed and only 27.4% survived the encounter, crossed and moved on. Naturally these figures cannot include a) birds that might have encountered a major road but were never recovered, or b) recovered birds in the "may never have encountered a major road" category that did. However, it seems unlikely that birds which encountered a major road and survived were significantly under -recorded because of the infrequency of live sightings from major roads (see 6.6.5).

In the case of birds that must have successfully crossed a major road, the crossing place was inevitably unknown. It is probable that some first encounters with major roads were, by chance, in places that lacked rough grass verge on both sides of the road and/or where the road was sunken, thus making crossing less dangerous (see A1.12).

Barn Owl road casualties
Photo: David Ramsden

9.6.4 What happened to survivors?

Some birds definitely survived a major road crossing and moved on (n=17). Their subsequent finding circumstances (major road/minor road/non-road) were evenly spread between known death-causes (Table 9.2), which suggests that the chances of them becoming major or minor road casualties may have been unaffected by the encounter. Unfortunately the sample sizes in each category were very small (n=3).

9.6.5 Major roads as barriers to dispersal

Almost three quarters of the birds that were known to have encountered a major road were killed and it is suggested that the majority of Barn Owls that encounter major roads do not survive the experience. There is no suggestion that major roads present a physical barrier to Barn Owls or that birds which encounter them were “forced” to turn back. Rather, the suggestion is that major roads act to divide Devon into four major areas, bordered by major roads and the sea, between which the transfer of first-year Barn Owls is suppressed. In this way roads act as partial “barriers” to dispersal.

9.6.6 The effects of restricted dispersal

After post-natal dispersal, Barn Owls are highly sedentary and spend the rest of their lives within a home range extending to about 1 km radius in the nesting season and up to 5 km radius in winter (Cayford 1992; Taylor 1994). The mortality of adult Barn Owls is generally lower than the first year mortality rate of 65-75%. Even so, most adults do not live long. Second year mortality is generally 40-60% and the third year rate 30-40% (Taylor 1994). Traditional nest sites can only be maintained by the regular arrival of first-years to replace adults that have died. In addition, where new foraging habitat is created and nestboxes erected, sites will normally only become occupied by the arrival of first-years, because adults do not generally move. The falling number of occupied sites (Grant *et al.* 1994) is indicative of a lack of young incoming birds.

The chances of Barn Owls encountering major roads are related to how far they disperse. Although food supply exerts a powerful influence on adult mortality, number of young produced and population density (Taylor 1994), dispersal distance is not related to population density (Marti 1999), food supply (Taylor 1994), or year (Percival 1990). Therefore, the influence of major roads as “barriers” to dispersal will impact the population every year irrespective of changing population density.

It is suggested that in landscapes with major roads, high density/highly productive Barn Owl populations will “export” fewer birds to maintain populations in “sink” areas (see 1.3.1); medium density/averagely productive populations will be less able to recover from natural short-term declines; and low density/low productivity populations (sink areas) will receive fewer incoming juveniles and be more vulnerable to local extinction. In this way, major roads may have played a significant part in Barn Owl population decline in parts of Britain, as in The Netherlands (De Bruijn 1994).

Chapter 10 – Can the Probability that Juveniles Will Encounter a Major Road be Calculated?

10.1 Summary

Breeding Barn Owls can only make a net contribution to the maintenance or expansion of the po pulation if their young have a reasonable chance of surviving until breeding age. Encouraging birds to nest at sites from which their dispersing young are likely to encounter major roads may be a waste of conservation resources. This study investigated the probability that a juvenile Barn Owl dispersing from its natal site will encounter a major road.

Sites where the total number of Barn Owls ringed was known were selected (n=79). Of the 891pulli ringed at these sites, the finding details of 137 birds were known. For each ringing site, distance to the nearest major road in 36 different directions was measured, each direction being separated by 10 ° around a 360° arc. The distance and direction moved by ringed Barn Owls from each site was used to determine a probability value that any juvenile dispersing from that site would encounter a major road.

The probability of a juvenile from the most remote nest site encountering a major road was only about 2% and the highest value was just over 50%. Due to the probab le biases contained in ring-recovery data, it is suggested that these are maximum values. Encouraging birds to occupy sites with a high major -road-encounter risk may be a waste of effort because the chances of the adult pair producing any dispersal -survivors are significantly reduced.

For any given nest site, an encounter rate can be calculated by quantifying distance to the nearest major road in all 36 directions and calculating a median value.

10.2 Background

10.2.1 The targeting of Barn Owl conservation effort in relation to major roads

In recent years much effort has been made to secure existing Barn Owl sites and increase the number of sites, breeding success and survival, through the improvement of foraging habitat and provision of nestboxes (DCC 1998). In order to be of greatest benefit, it is prudent for the limited resources available for Barn Owl conservation to be directed away from areas where Barn Owl mortality is unusually high and it has been suggested that Barn Owls should not be encour aged to establish themselves at sites close to major roads by the provision of nestboxes (Hill 2001).

In the case of adult Barn Owls, which normally stay in the same home range throughout their lives, a "safe" distance may be greater than their maximum fo raging range of < 5 km in winter (Taylor 1994). Most foraging by nesting adults is within 1 km of the nest (Cayford 1992; Taylor 1994). The Barn Owl Trust recommends that nestboxes are not erected within 1 km of a major road unless Barn Owls are already present (BOT 1989) and the UK government recommended that sites for the release of captive Barn Owls should "be more than 0.5 km from major roads; ideally the distance should be 2 to 3 km" (DoE 1995). However, the idea that there are safe distances at which birds should be encouraged reside with respect to major roads is not based upon published research.

Barn Owl numbers are in part determined by the recruitment rate of juveniles into the adult population. Indeed, Percival (1990) showed that first-year survival rate exerts a more powerful influence on overall Barn Owl population level than any other life cycle parameter. Therefore, nesting pairs can only make a net contribution to the maintenance or expansion of the wider population if their young have a re asonable chance of survival. Encouraging Barn Owls to nest at sites from which their dispersing young are highly likely to encounter major roads may be a mistake.

10.2.2 Geographical extent of the effect of major roads

If major roads suppress local population density it is likely that the effect diminishes as distance increases. The same may apply to the chances of young dispersing from any given nest site becoming major road casualties. The geographical extent of the effect of major roads on local Barn Owl populations has not been investigated. Nevertheless, Shawyer & Dixon (1999) recommended to the Highways Agency that Barn Owls should be encouraged by the provision of rough grass corridors and a "comprehensive program of nestbox provision", to nest as close as 100 metres to major roads.

Once a Barn Owl has become sedentary (normally by late November in its first year) its chances of ever encountering a major road are small unless its main roost/nest is within 5 km of a major road. It could be argued that encouraging adults to reside within 5 km of a major road is a waste of effort. However, home ranges are not generally circular (Cayford 1992) and it is often difficult to predict where birds from any particular site may forage. It is probable that some adults that nest annually within 5 km of a major road never encounter it. Even if most adult Barn Owls did forage up to 5 km <u>in all directions</u> from their main roost/nest, it is evident that many pairs would never encounter major road because many potentia l Barn Owl home ranges do not contain any. Sixty three percent of Devon is more than 5 km from a major road. However major roads pose a much greater danger to juvenile Barn Owls because they often move relatively great distances in dispersal.

It is probable that young birds dispersing from natal sites close to major roads are more likely to encounter a major road than those dispersing from a greater distance. However, the probability of any given site producing such encounters is unlikely to be simply a m atter of the distance to the nearest major road. Considering the minimum distance takes no account of the direction in which young may disperse, which is random (see Chapter 5). The chances of any bird dispersing directly towards the nearest section of a major road must be small.

Chapter 7 looked for a relationship between major road density within 10 km of the nest and the proportion of ringed pulli reported as major road casualties. No statistically significant correlation was found. Where a section of major road was present within 10 km, it never surrounded the ringing site and was normally present in an arc of less than 180°. It was not possible to assess risk by measuring road length within, for example, 10 km, or by measuring distance, because both me thods failed to take account of direction. The probability of a bird from any given site encountering a major road was likely to be affected by the distance to the nearest major road in all directions. For example, a site two kilometres away from the only major road in an area may be safer than a site situated mid -way between two major roads ten kilometres apart.

Photo: David Ramsden

10.3 Aim

To examine the movements of individual ringed birds in relation to the distribution of major roads in Devon and to devise a method for calculating the probability for any specific site that a juvenile Barn Owl dispersing from that site will encounter a major road.

10.4 Data Used

In the period 1985–1999 there were 79 Devonian ringing sites where the total number of pulli ringed was known. At these sites a total of 891pulli were ringed and the finding details of 137 birds were recorded. These ringing sites were plotted on a map showing the distribution of all major roads.

Exclusions: Four birds recovered at exceptionally long distances (two to Wales, one to Wiltshire and one to east Somerset) were excluded. A ringing site on the border of east Devon was also excluded as it produced only one recovery – a bird that moved 53 km east.

10.5 Methodology

For each ringing site, the distance to the nearest major road in 36 directions at 10 ° intervals was measured. For a direction in which there was no major road, a distance value of 101 km was recorded, so as to be in excess of the maximum owl movement recorded (96 km) within the data used. Thus for each site, thirty-six distance values were generated. The analysis used this information together with data on the distance and direction moved by ringed Barn Owls to generate a probability value for each ringing site.

The value required was for the probability of birds from any given site encountering a major road rather than dying on one. Thus, the encountered sample included all birds found dead or injured on a major road and those classified as having crossed one or more major roads (see Chapter 9).

Those birds moving less than 1 km were coded by BTO as having moved 0 km and were given an orientation of 360°. These birds were used in the analysis so as not to introduce a distance bias to the results, although their movement was set to 0.5 km and the direction band retained as 360°.

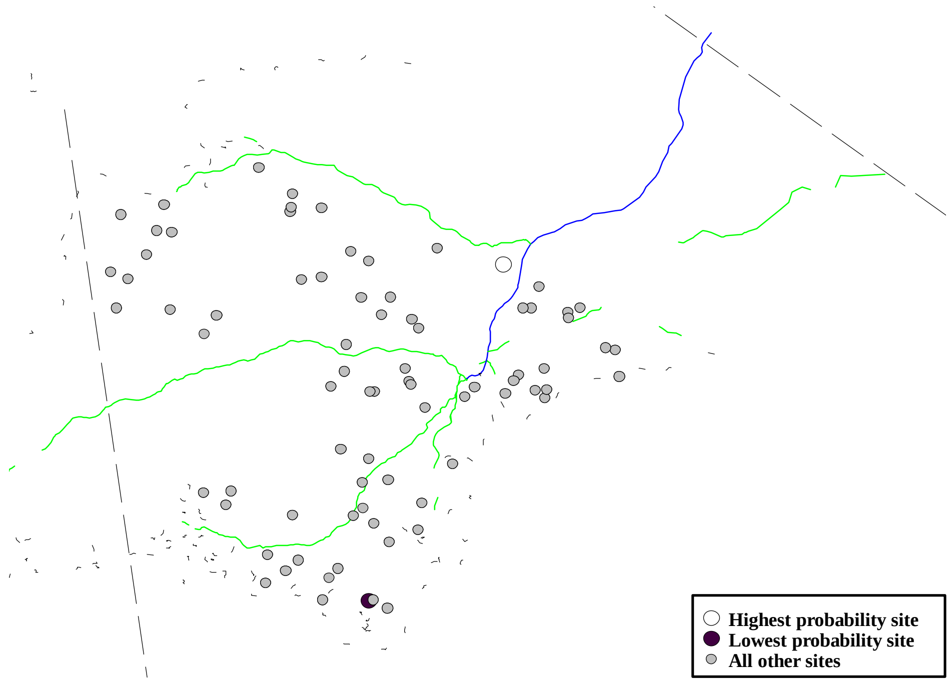
Using SAS (SAS Institute 1996), a randomisation procedure was employed on a site-by-site basis. One owl movement (retaining distance and direction together) was selected at random from the 137 available. This was then compared against the matching direction band for the site being modelled to see if the owl's movement took it as far as the nearest major road within the distance band. This procedure was repeated 1,000 times for each site to generate a probability value based on the number of times in which a randomly selected real owl movement away from the site encountered a major road.

10.5.1 Limitations of the method

The geography of Devon presented some difficulty. Numerous ringing sites were situated next to landscapes that would have influenced the bird's dispersal, namely, the sea (to the south east and north west) and Dartmoor (an upland area to the south of central Devon). In both cases no allowance for this was made. Distance measurements from ringing sites to the nearest major road that traversed Dartmoor were measured as normal. Measurements into the sea were allocated a value of 101 km (see above).

10.6 Results

Map 10.1 shows the distribution of the Devonian ringing sites used and major roads, in the extended study area.



Map 10.1 *The extended study area showing the distribution of major roads and Barn Owl ringing sites in Devon , where the ringing total was known. The sites with the highest and lowest calculated probability of producing juveniles that encounter a major road are shown.*

Out of the 891 pulli ringed, 15.4% (n=137) were subsequently reported and 59 of these are known to have encountered a major road. Within the 137 real owl movements the distances (ringing site to finding place) ranged from 0.5 km to 96 km. The distances between ringing sites and major roads in 36 directions varied from 0.5 km to 92.1 km (n= 4,932). No sites were completely surrounded by major roads (see map 10.1) and therefore the artificial distance value of 101 km occurred at least once in every set of 36 distance measurements.

From the 1,000 runs for each site the calculated number of encounters ranged from 24 (2.4%) to 505 (50.5%) and the geographical location of these two sites (min. and m ax. values) is shown on map 10.1. The distribution of calculated encounter rates (CER) across sites is shown in Figure 10.1, which approximated to a normal distribution with some skew towards the lower end of the range.The median CER was 245 (24.5%).

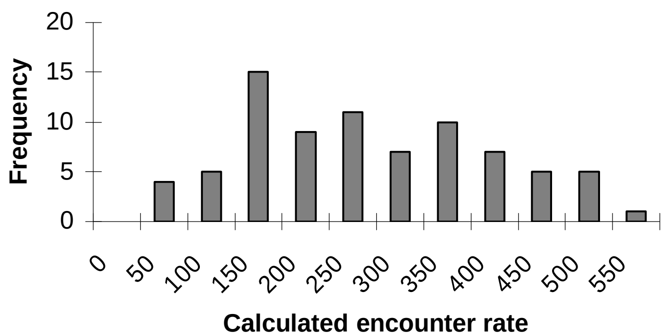


Figure 10.1 *Distribution of encounter rates across sites*

As expected, there was a positive correlation between the median distance from a site to the nearest major road in all directions and the CER value of that site (value –0.71); ie. as the median distance to major road/s increased so the CER decreased (see figure 10.2). Note the strength of the association over the first 30 km. The same trend was observed in Map 10.2 – sites that were closer to and more surrounded by major roads had a higher probability value, as expected.

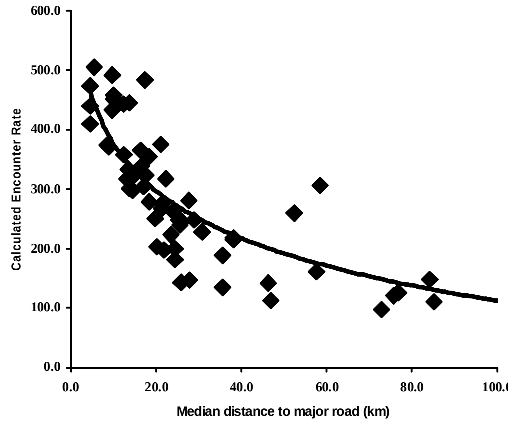


Figure 10.2 *Relation of median distance to calculated encounter rate*

Among the 79 ringing sites, a total of 819 birds were ringed. Using the individual site ringing totals and details of the 137 reported recoveries, the proportion of birds from each site that were known to have encountered a major road was calculated. These real values were compared to the calculated encounter rate. 44% of sites did not produce any recorded encounters and t he mean CER of these was 193.4. Conversely, from 19% of sites (15 out of the 79) at least 20% of all ringed birds were known to have encountered a major road; these sites had a higher mean CER of 291.7. Figure 10.3 indicates a positive correlation between recorded encounters and the calculated encounter rate. However, the correlation was not statistically significant.

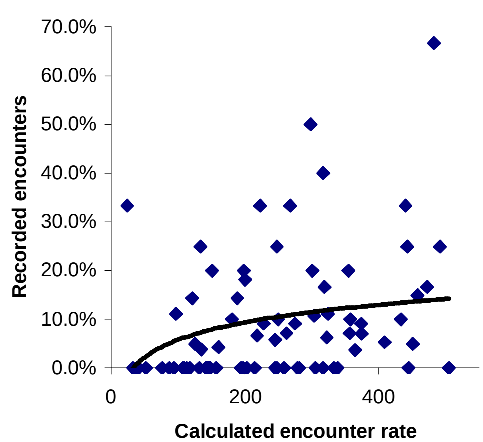
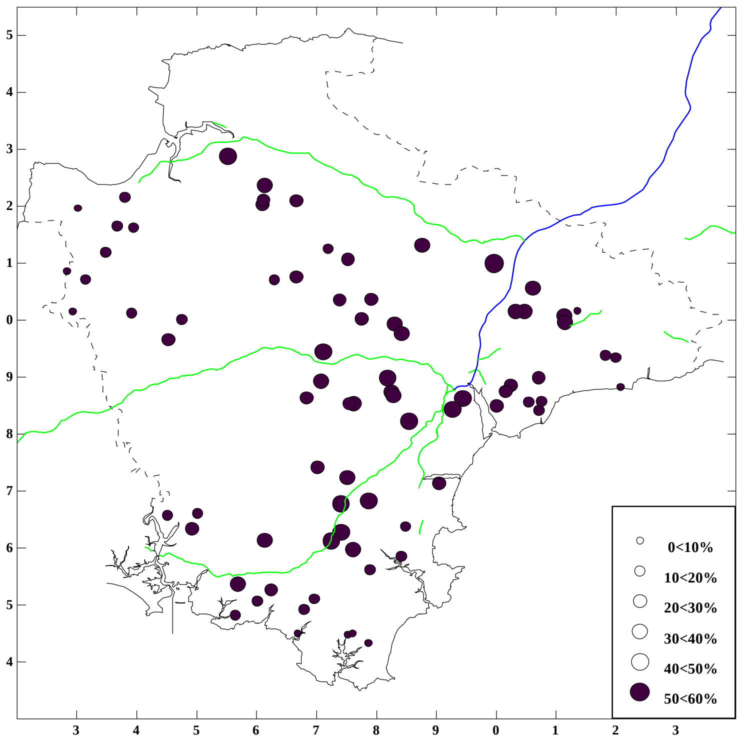
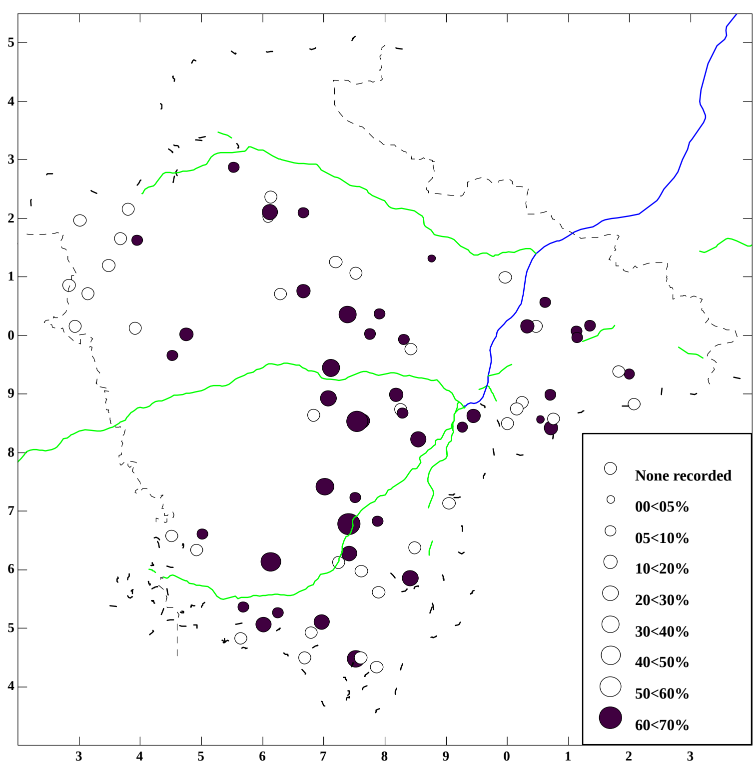


Figure 10.3 *Proportion of ringed birds recorded as having actually encountered a major road as a function of calculated encounter rate; all sites, n=79.*



Map 10.2 *The distribution of motorways, dual carriageways and other major roads in Devon showing Barn Owl ringing sites size-scaled to indicate the calculated probability of juveniles from each site encountering a major road during dispersal (CER – see text).*



Map 10.3 *The positions of motorways, dual carriageways, other major roads in Devon and Barn Owl ringing sites size-scaled according to the proportion of ringed young from each site that were subsequently recorded as encountering a major road.*

There was considerable variation in the numbers of birds ringed at each site and less than six birds were ringed at 40% of all ringing sites. Thus, many of the atypical data points in Fig. 10.3 may have bee n the result of small sample sizes. Only 15% of sites had ringing totals in the range of 20 to 60 pulli. By considering only these sites, the positive relationship between theoretical CER and actual recorded encounters is more clearly shown (see figure 10. 4).

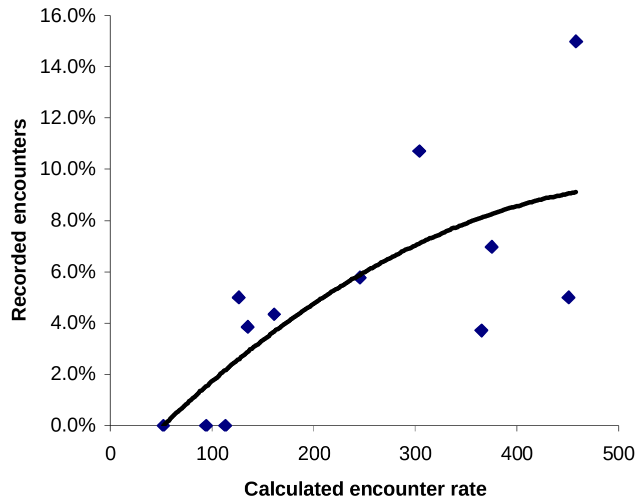
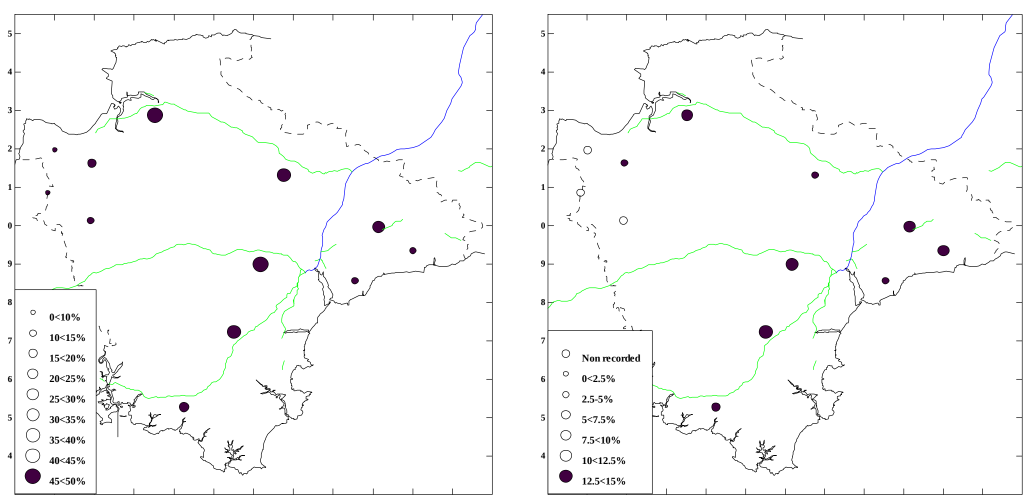


***Figure 10.4** Proportion of ringed birds recorded as having actually encountered a major road as a function of calculated encounter rate, based upon a sample of 12 sites where >20 birds were ringed (total number of birds = 385).*

The distribution of these 12 sites in relation to major roads in the county is shown in Map 10.4. A comparison of the relative symbol sizes between each map reveals the similarity between the actual and calculated probability of encountering a majo r road.



***Map 10.4** The position of motorways, dual carriageways and other major roads in Devon and Barn Owl ringing sites where at least 20 pulli were ringed (n=12).*
<u>Left Map</u>: Ringing sites size-scaled according to the calculated probability o f juveniles from each site encountering a major road during dispersal (CER).
<u>Right Map</u>: Ringing sites size-scaled according to the proportion of ringed young from each site that were subsequently recorded as encountering a major road.

10.7 Discussion

10.7.1 Calculated encounter rates

Compared to some counties in Britain (for example, Berkshire, Hertfordshire or Greater Manchester), Devon is a large area with few major roads. In spite of this and the widespread distribution of Barn Owl sites used in the study, there were no sites where the calculated encounter rate was zero. However, the probability of a juvenile dispersing from the most remote site encountering a major road was only about 2% during the period of its dispersal. Therefore the impact of m ajor roads on the overall survival of young from some remote sites was likely to have been negligible.

It is interesting to note how calculated encounter rate (CER) is influenced by encirclement. Some nest sites in remote areas had high CERs, not because they were close to a major road but because they were more encircled. Sites with the highest CER were those that were close to a major road and had a high degree of encirclement. Because recoveries of ringed birds are skewed towards shorter recovery distances, the influence of encirclement reduces with distance. For this reason, only one site had a CER in excess of 50%. Higher CER values would occur in parts of Britain with a denser major road network, especially where inter-connecting roads produced bloc ks of land which are entirely surrounded by major roads.

The highest CER value in Devon was just over 50%, ie. the chances of every juvenile dispersing from this site encountering a major road was 50/50 during its dispersal period. It can be argued that e ncouraging birds to occupy such sites is a waste of effort because the chance of the adult pair producing any dispersal-survivors is small (see below).

When considering the impact of major roads on the survival of birds from any given site, the calculated encounter rate may under-represent true impact. Thus, although the CER figure applied to all birds from that site, the encounters were only made by the minority of birds that dispersed further and lived longer than the rest (see 8.1).

The median encounter rate of 25% means that, overall, one -in-four Devonian Barn Owls was likely to have encountered a major road. Chapter 8 suggested that by the time the encounter occurred, most of the others had already died of a non -major-road cause. Chapter 6 suggested that when individual Barn Owls encountered a major road they very quickly became casualties.

10.7.2 Calculated Encounter Rate (CER) and the median distance to major roads

The maximum attainable distance from the nearest major road in the extended stud y area was 92 km, but in Devon only it was circa 25 km. Roughly two -thirds of Devon lies within 10 km of a major road. Figure 10.2 shows a positive correlation between CER and the median distance between individual sites and the major roads around them. This suggests that a theoretical encounter rate for any site can be calculated by measuring the distances to the nearest major road in all 36 directions and simply calculating a median value.

10.7.3 Comparison with recorded encounters

The proportion of birds that were known to have encountered a major road was calculated from the ringing total from each site and ring recoveries of birds from the site. (For example: if 10 birds were ringed at a site and two were reported as major road casualties and one had crossed a major road, the recorded encounter rate was 30%). However, the results were often skewed by the very low ringing totals for many sites. (For example, at the site with the highest CER (50%) only four birds were ringed and the only recovery was a non-encounter, giving an actual encounter rate of 0%. At the site with the lowest CER (2%) only three birds were ringed, but one was reported as a major road casualty, giving an actual encounter rate of 33%.) For this reason, sites that had ringing totals in the range of 20 to 60 pulli (n=12) were considered separately and a positive correlation between theoretical CER and actual recorded encounters was more clearly evident (see map 10.4).

The geography of Devon could have influenced the dispersal routes of some birds and this may have contributed to the correlation being non significant (see 10.5.1). Further research using larger sample sizes in a more uniform landscape would clearly be of interest.

The average calculated encounter rate of 24.5% was higher than the actual recorded encounter rate of 6.6%, but this is to be expected, since only 15.4% of all ringed Barn Owls were subsequently reported (a similar figure to the overall British recovery rate of 14.4% reported by Percival 1990). When allowance for the recovery rate is made, the actual recorded encounter rate is surprisingly high compared to the CER.

The fact that the proportion of calculated encounters that were actually recorded (26.9%) is higher than the recovery rate (15.4%) suggests that recovery data is biased towards birds that encounter major roads. Indeed, more than half of Barn Owls that were known to have encountered major roads were major road casualties. However, in the detailed review of biases (see 6.6.2) it is suggested that major road casualties are less likely to be reported than minor road casualties. Because 41% of the birds that probably did not encounter a major road were recorded as minor road casualties it is doubtful that road recoveries are highly biased towards major roads. However, to some extent recoveries must be biased towards road casualties and therefore the CERs should be considered as maximum values.

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Appendix 1

Barn Owls and roads, evidence of effects, causes and circumstances – a literature review

A1.1 Percentage of ring recoveries that are road casualties

In Britain most data on Barn Owl mortality arises from recoveries of ringed birds, mainly reported by the public and held by the British Trust for Ornithology (BTO). Compared to most other bird species, the recovery rate of ringed Barn Owls is high:13.7% for first year birds and 15.1% for adults (Percival 1990). At the BTO, David Glue (1971) showed that the proportion of Barn Owl ring recoveries that were reported as road casualties between 1910 and 1954 was 6% and this rose to 15% for the period 1955 -1969. In 1990 the BTO divided the recoveries into birds recove red within a year of ringing (first-years) and older birds (adults). Again, there was a marked increase. Between 1944 and 1988 the proportion of Barn Owl recoveries reported as road casualties rose from 14.3% to 32.4% (adults) and from 27.3% to 49% (first years) (Percival 1990).

In 1989 a newly formed study-group (The Barn Owl Trust) published its first report showing that of 71 nestlings BTO ringed in the period 1986-1988 in the county of Devon, 61.5% of all recoveries reported by September 1989 were road casualties (Ramsden & Ramsden 1989). Using a different sample of 173 Devonian Barn Owls ringed in the period 1986-1992, the Barn Owl Trust showed that 40% of all recoveries reported up to the year 2000 were road casualties (Green & Ramsden 2001). This lo wer figure may be accounted for by the extended reporting period during which thousands of roost/nest sites had been searched, thus reducing the bias towards road recoveries (personal observation).

It is widely acknowledged that ring-recovery data is biased towards road casualties. In The Netherlands, De Bruijn (1994) separated ring recoveries reported by the public from findings of unringed birds by owl researchers and found that in the reports of ringed birds (n=48) road casualties represented 56% of all reports, but in the unringed sample (n=42) 24% were road casualties.

A1.2 Percentage of found-by-road-search birds that are Barn Owls

Amongst the available literature are several studies based on systematic searching for casualties on particular roads. Bourquin (1983) reported the deaths for raptors and owls recorded by road maintenance staff over a seventeen year period along a 36.9 km stretch of autoroute (motorway) in Switzerland. Of 80 dead owls, Barn Owls were the most frequently found (55%). In n ortheastern France two separate road-search studies were carried out. In one of these, 259 km of autoroute was searched three times a day for four years and a total of 1,028 owl victims were found, of which 674 (65.5%) were Barn Owls (Baudvin 1997). Massemin & Zorn (1998) systematically searched a 150 km stretch of autoroute for four years and out of 173 owl casualties, the vast majority (85.5%) were Barn Owls. In these studies no attempt was made to quantify the relative abundance of Barn Owls in the road -adjacent landscape. Therefore the extent to which the number of Barn Owls killed may have been disproportionate is unknown.

In Britain, a 50 km stretch of busy major road with single and dual carriageway sections was searched every 48 hours between 1996 and 1998 during September to November and January to March. All owl and raptor casualties were photographed and details recorded including sex, age, precise position and verge habitat (Shawyer & Dixon 1999). Of the 155 owl casualties which were discovered , 65.8% were Barn Owls (n=102).

The number of Barn Owl casualties reported per year per 100 km of major road in the four separate road-search studies was:-

Switzerland	7 casualties/100 km/year
Northeastern France (1)	65 casualties/100 km/year
Northeastern France (2)	25 casualties/100 km/year
Britain	68 casualties/100 km/year

However, direct comparison is problematic as the methods (search type and effort), the species' population density and other variables were far from constant. What is cl ear, however, is that, of all owl and raptor casualties found on major roads, Barn Owls are by far the most frequent victims (Bourquin 1983; Baudvin 1997; Massemin & Zorn 1998; Shawyer & Dixon 1999).

A1.3 Percentage of found-by-general-search birds which are road casualties, including age-class

Investigations based on searches for corpses along roads cannot determine the relative importance of road deaths in relation to other mortality causes. This may, however, be achieved by searches that are not road based and include roost/nest sites, open ground and other places where starved birds or other non-road victims may be found.

Between 1980 and 1986, during his intensive study of Barn Owls in Scotland, Iain Taylor (1994) carried out systematic monthly searches of roost sites looking for corpses. In addition he asked farmers and others to look out for them and drove along most of the roads. In this way,138 dead first year birds and 66 older birds were found. Of the older birds, 65.2% were found in an emaci ated condition at known roosts and 22.7% were road deaths. Of the first year birds, 33.3% were dead at roost sites and 56.5% were found dead by roads (Taylor 1994). Taylor thought that the number of young birds dead at roosts was probably underestimated as they were more likely than adults to roost in unpredictable places and therefore less likely to be found.

Although Taylor's mortality results probably contain some inaccuracies, the methods used provide a much more reliable assessment of road deaths than figures based on ring-recoveries or road searches. In spite of this and the low density of roads in Taylor's study area, a notably high proportion of mortality (22.7% – 56.5%) occurred on roads.

A1.4 Time of year road casualties are found and their age-class

At the British Trust for Ornithology, the seasonal mortality in Barn Owls was first examined in 1973, using 205 recoveries of ringed first-year birds and 124 recoveries of older birds. Juvenile mortality was at its highest in September and around half of these were recovered on roads, railways, or overhead wires. No similar peak was observed amongst older birds (Glue 1973). Unfortunately in this first BTO study road casualties were not treated separately and sample sizes within months were small .

Through the seventies and eighties increasing numbers of Barn Owls were ringed, which increased the recovery sample size and in 1990, Steve Percival integrated data from a variety of sources, including all BTO ring recoveries and nest records, in order to identify which stages of the owl life cycle were most important in determining population levels. The dominant key factor affecting Barn Owl populations in all regions was found to be post-fledging (juvenile) mortality (Percival 1990). In the context of this report Percival's results are very important: post-fledging survival rate exerts a more powerful influence on overall population level than any other life-cycle parameter. Therefore road mortality may be a significant cause of population decline if it comprises mainly young birds which might otherwise have survived.

Taylor (1994), showed that first-years were found mainly in autumn and winter and adults were found mainly in winter. Using much larger datasets, Percival (1990) showed a very similar pattern: juveniles died mainly in September-October-November and adults died mainly in February-March-April. Unfortunately, in presenting the seasonal pattern of deaths, neither author treated road casualties separately. Most information on the age class of road victims came from road-search studies.

Bourquin (1983) showed that owl mortality (of which 55% were Barn Owls) on a Swiss autoroute was low in summer, rose in the autumn and peaked in November and again in February. Unfortunately, Bourquin was another author who did not provide information on the age-class of casualties. Massemin et al. in northeastern France did investigate the age of Barn Owl autoroute victims and showed that the ages of intact birds (n=127) killed throughout the year showed significant seasonal differences. Autumn mortality, which peaked in November, consisted of 84% juveniles. Winter mortality peaked in February and comprised <65% adults and 35% juveniles. Massemin et al. (1998) suggested that autumn and winter mortality was partly related to the concomitance between the daily peak in traffic density at 17.00 h and the onset of Barn Owl hunting activity following sunset.

In Britain, Shawyer & Dixon (1999) reported that in each of the three years of their study, Barn Owl mortality peaked in October-November. Considering only birds of known age found on the frequently searched road (n=34), 71% were juveniles (see A1.2).

Out of 10 birds found in the autumn (Sept-Oct-Nov), 9 were juvenile and only 1 was an adult, whereas in winter (Dec-Jan-Feb) the ratio of juveniles to adults was closer - 12 juveniles to 5 adults (Shawyer & Dixon 1999, fig. 2b). Another sample of 135 Barn Owl road casualties, including birds from a variety of trunk roads and motorways in central and southern England, collected using less frequent searches, showed a similar pattern. The overall majority (70%) were juveniles. Of 53 found in the autumn, 46 were juveniles (87%), whereas in winter the ratio of juveniles to adults was again closer - 40 juveniles to 23 adults (Shawyer & Dixon 1999, fig. 2a).

Based on reported sightings of live birds, it was suggested that Barn Owls avoided road verges during peaks of traffic density and therefore the seasonality of mortality could not be explained by the concomitance of traffic density and Barn Owl activity peaks as suggested by Massemin et al in 1998 (Shawyer & Dixon 1999).

Thus, evidence to date shows that most road casualty Barn Owls are juvenile first year birds and that there are two main road death seasons: juvenile deaths in autumn and juvenile and adult deaths in winter.

A1.5 Why are so many Barn Owls found on roads?

Within the literature, the most popular theory is that Barn Owls hunt prey-rich road verges and are struck whilst flying over the carriageway (for example Bourquin 1983; Schulz 1986; Taylor 1994; Baudvin 1997; Massemin & Zorn 1998; Shawyer & Dixon 1999). However, this would not explain deaths on roads that lack prey-rich verges. It has been suggested that field voles are absent from road verges that are less than 4m wide (Bellamy et al. 2000).

It is possible that Barn Owl deaths occur whilst birds are simply crossing roads rather than using them or their verges for foraging. Two studies have shown that major road deaths are more likely to occur where roads traverse linear habitat features along which the birds may hunt (Shawyer & Dixon 1999; Garland 2002).

The extent to which deaths may be a result of verge habitat, other factors, or simply accidental, is difficult to determine as there is a severe shortage of documented eye-witness accounts of Barn Owl behaviour on roads or road verges. This suggests that Barn Owls may be seen alive on roads less often than they are found dead. Indeed, the author has studied Barn Owls for seventeen years, regularly driving at night on a variety of roads, including motorways and dual carriageways, looking out for Barn Owls and has never seen a live Barn Owl whilst on a major road although numerous casualties have been found (personal observation).

A1.6 To what extent do Barn Owls hunt the verges of roads?

Bouquin (1983), discussing birds of prey, including owls, stated that the attraction of the Geneva - Lausanne autoroute was a combination of prey-rich verges and road-side fence posts, where hunting birds often perched, but this appeared to be based on sightings of diurnal birds, mainly Buzzards Buteo buteo. In California, Schulz (1986) who reported 912 dead Barn Owls found during 24,542 miles of driving, stated that more Barn Owls were found dead on stretches of highways that had vegetation in the central reservation as well as the outer verges, which suggests that the birds were hunting the central reservation. In Britain there was one documented sighting of a Barn Owl hunting the central reservation of a major road, the A1 (Owens 1997). Mason (1997) stated that Barn Owls had been seen “hunting by the sides of roads on several occasions” but no other details were given.

In France, Baudvin (1997) compared the finding places of autoroute casualties to the surrounding landscape categorized as forest, cereal fields, meadows and sand pits. Barn Owl victims were found along roads bordered by cereal fields in greater proportion than their availability, which suggests that either the birds used the cereal fields more than other fields and were killed whilst crossing, or that the verges adjacent to cereal fields were used more than other verges. The suitability of the verges for small mammals was simply classified as rich or poor. Half of the road verge (50.3% of 518 km) was classed as rich vole habitat, but significantly more than half of Barn Owl casualties were found beside them (74%). This suggests that many of the birds found dead had been attracted to their finding-places by the suitability of the verges as foraging places. However 154 Barn Owl casualties (26%) were found beside “poor” verges and no reason for the birds’ presence was suggested (Baudvin 1997).

In England, Garland (2002) investigated the distribution of Barn Owl corpses on a major road in relation to the distribution of grassy verge habitat. Because a large proportion of road verge was dominated by rough grassland and the number of Barn Owls in the sample was only 24, Garland did not find a positive correlation and stated that a very large sample size would be needed in order to detect any subtle relationship between Barn Owl road casualties and this habitat (Garland 2002).

Shawyer & Dixon (1999) investigated a 50 km section of the A303 in southern England. As a result of an extensive media campaign lasting three years, 56 sightings of live Barn Owls seen along the 50 km section by the public were recorded. Of these, 2% were of birds being mobbed, 56% were of birds flying directly across the road and 42% were of birds classed as "engaged in deliber ate and active flight or post roosting/hunting on the verge itself". When the stomach contents of road casualty Barn Owls were examined, more than half of the birds contained food items. In half of these, the level of digestion was "low" (5-40%) suggesting that the prey had only recently been consumed (Shawyer & Dixon 1999). However, it was not possible to determine if the food items had been caught on the road verges or elsewhere. No comparison was made with the level of digestion in the stomachs of non -road casualties. The exact position of corpses in relation to obstructions such as trees and scrub in linear rough grass verges suggested that the birds had been flying along the verge (Shawyer & Dixon 1999).

One study attempted to use radio tracking and direct observation to investigate Barn Owl behaviour in relation to a nearby motorway. However both methods proved ineffective and were abandoned (Garland 2002).

In the absence of expert observations of Barn Owl behaviour along roads and the lack of researc h based on radio-tracking of Barn Owls encountering roads, it is not possible to describe their behaviour in detail. There is a lack of published data concerning the extent of the use of road verges, even by diurnal raptors (Meunier et al. 1999).

In summary, the available evidence suggests that Barn Owls fly directly across roads and, to some extent, that they also hunt the verges of major roads.

A1.7 Do Barn Owls use roads as dispersal corridors?

Shawyer and Dixon (1999) suggested that during their post-fledging juvenile-dispersal phase, Barn Owl flight paths are along linear habitat features such as rough grassland corridors associated with rivers streams and ditches, although no evidence for this was presented. No suggestion was made in relation to the dispersal flight paths of birds in more undulating and hilly landscapes (ie. most of Britain) where these habitat features are generally absent.

The suggestion was also made that young Barn Owls use road verges as "dispersal corridors" (Shawyer & Dixon 1999) but again there appears to be no evidence for this. In order to disperse along road verges, Barn Owls would need to survive in such places. The evidence that they do not survive is compelling (see above).

In a major review of literature on the ec ological effects of roads and traffic, Spellerberg (1998) stated that there is very little evidence to show that roadside verges are used by animals as conduits for dispersal.

A1.8 How do they actually die and in what position in the road are they found?

It may be important to consider the way/s in which deaths occur, so as to facilitate risk assessment and to determine the likely value of preventative measures or mitigation.

Again there is a general lack of detailed information, but various authors h ave nevertheless made suggestions. Glue (1971) stated "observers noting the manner in which owls are killed at night mention birds hit while rising from the road surface, birds flying directly into moving vehicles and birds struck a glancing blow while flying low across the road." Jane Ratcliffe (1977), a pioneer of owl rehabilitation, reported that amongst road casualties, right wing fractures outnumbered left wing fractures by more than two to one. She believed that "whilst crossing the near -side traffic lane they are only three to five feet in height and so are hit by cars, suffering broken right wings. On reaching the outside traffic lane, however, they have usually gained sufficient height to clear a car." Bourquin (1983) suggested that "collisions with cars probably happen when birds are flying away from roadside posts or from the ground after they have caught prey". Massemin & Zorn (1998) found that 55% of owls, mostly Barn Owls, were found in the emergency stopping lane (hard shoulder) and only 18% in the median strip (central reservation) and stated "it appears that impacts probably occurred at the edges of the highway when owls first started to cross the road". They continued "it appeared that many of the owls were not killed by direct impact with vehicles but by impact with the ground after they were projected up into the air by the turbulence behind vehicles".

Illner (1992) reported that he personally had three near misses with Barn Owls whilst driving at 60 -80 km/h, "1-2 metres from the car's windscreen".

Shawyer & Dixon (1999) reported that injuries were not biased towards either side of the body and that roughly half of road casualties showed no sign of fractures or other serious bodily injury. However half of these did show mild bruising to the head. The conclusion drawn was that rather than being struck directly, a significant number die from shock and hypothermia after being caught in vehicle turbulence. 50% of road casualties were found in the "road gutter" and the remainder were split equ ally between the road verge and the road surface. Shawyer & Dixon (1999) also stated "The specific points where the vast majority of victims were found could be linked to places on the road verge where continuous lengths of open rough-grassland are abruptly interrupted by an unfavorable habitat type. This commonly involved a belt of bushes or trees or at a spot on the verge where a road or bridge intersected a stretch of grassland. It is at these points that Barn Owls in an attempt to skirt these interfaces which are likely to be seen as an obstacle to hunting, are believed to be at their most vulnerable, straying onto the road itself and into the path of vehicles".

Another way in which fatalities may occur is through owls struck by vehicles whilst standin g on, or rising from, the road surface. The author has, on several occasions, witnessed a Tawny Owl *Strix aluco* standing motionless on the road surface for no apparent reason (personal observation). This phenomenon has also been witnessed by others, involv ing Barn Owls, but seems to be under-recorded in available literature. The Barn Owl Trust has collected several thousand sightings of Barn Owls from the public and has recorded this phenomenon approximately ten times. In one case a Barn Owl was seen standing motionless on a road surface for five minutes before flying off (unpublished record). Owens (1997) reported, "two unharmed birds were seen sitting in the road, perhaps after pouncing on prey". Glue (1971) suggested that hunters might prey upon mammals a nd beetles exposed whilst crossing the road surface. Another possible reason for this habit is the energy -saving use or enjoyment of heat that can radiate from a road surface at night. Mikkola (1983) quotes one sighting of a Barn Owl standing in a road perched on a road casualty Hedgehog *Erinaceus europaeus*. However, there seems to be a general consensus that Barn Owls do not generally feed on carrion.

A1.9 Are Barn Owls dazzled by car headlights?

Considering the ways in which road deaths occur at ni ght, Glue (1971) stated that "bright lights at night can cause temporary blindness in birds." Schulz (1986) stated "when confronted with bright lights while foraging at night, Barn Owls become disorientated, perhaps as a result of temporary blindness. They often move away from the light source, continuing in its path, but will occasionally fly directly towards it." Taylor (1994) acknowledged the possibility that "birds may be dazzled and confused by headlights at night". Shawyer & Dixon (1999) stated that t here was little evidence that being dazzled was implicated in any significant way in the deaths of Barn Owls.

Prof. Graham Martin, an expert in avian sensory science at The University of Birmingham, considered that "there is not much that can be said wit h certainty. Vertebrate eyes achieve their maximum sensitivity after about twenty minutes in the dark and if a bright light is shone into the eye, impairment of vision may be experienced. How long this lasts depends on how bright the light is and how long it is viewed. If a fully dark-adapted eye stared directly into a headlight, temporary blindness may result" (personal communication). Less extreme exposure may render the eye less sensitive and the vertebrate less able to cope with dark ambient conditions for a short period (Martin 1985). The effect of headlights in real -life situations is very difficult to assess. Various factors, such as the extent to which Barn Owls may avoid looking directly into headlights, are unknown.

A1.10 What factors might affect the chances of a road casualty being reported?

Generally, Barn Owl casualties are more likely to be reported than many other species, probably because they are large and often die in conspicuous places. In Britain, in the period up to 2000, 32,962 Barn Owls were ringed and of these 4,202 were subsequently recovered and reported (Clark et al. 2002), a recovery rate of 12.7%. However the probability of any individual road casualty being reported may be subject to a wide range of variables:

- ringed birds are more likely to be reported than unringed birds
- corpses may be removed by scavengers
- there may be temporal and spatial variation in scavenger effort
- corpses landing in tall vegetation are less likely to be seen
- corpse visibility may be influenced by road type
- flattened corpses are less recognizable and less likely to be handled
- corpses in the fast lane or central reservation are more dangerous to retrieve
- drivers may be less willing to stop on busier roads or at busier times
- drivers may be less willing to stop during wet weather
- it is illegal to stop on clearways and motorways
- there may be no safe stopping place nearby
- observer effort may vary according to road type, traffic density, weather conditions
- corpses under artificial road lighting may be more noticeable
- in highly littered areas, corpses may be less noticeable
- seasonal variation in corpse decay rate
- temporal and spatial variation in road verge maintenance work
- seasonal changes in owl mortality times in relation to temporal changes in observer effort

Generally, the potential influence of the above variables seems have been overlooked within the available literature. Two other possibilities include: 1) owls involved in minor collisions or serious near misses may be only slightly injured or suffer reduced fitness and may die later away from the road (Illner 1992); 2) the unintentional transportation of carcasses on vehicles (for an example, see Taylor 1994) is one way in which carcasses can be removed from the scene of impact, although the chances of such birds being found or reported may not be affected.

A1.11 Evidence of Barn Owls transported by vehicles after being struck

The unintentional transportation of carcasses on vehicles is acknowledged as a possible cause of some unusually long-distance ring recoveries (Taylor 1993; Clark et al. 2002). Taylor (1994) reported receiving six first-hand reports of this occurrence from truck drivers and related an eye-witness account of a Barn Owl struck by a coach which was transported 200 km before dropping off. Percival (1990) suggested that, as a result of this factor, the distances moved by road casualties might not be representative of the whole population. Taylor showed that the mean recovery distance of road casualties was 44.2 km (n=23) and compared this to a mean of only 9.1 km for non-road casualties (n= not given). Taylor conceded that his study area was unusual and stated that "there may be other explanations for these results, but transportation must at least be a contributory factor" (Taylor 1994).

A1.12 How do the physical characteristics of roads affect Barn Owls?

Some road-search studies have noted that casualties occur more often on raised (embanked) or level sections of major roads and less often on excavated (sunken) sections. Baudvin (1997) showed that in his study, 32% of Barn Owl casualties were found on the 44% of roadway which was sunken and 68% were found on the 56% which was level or raised. Similarly, Massemin & Zorn (1998), found that most owls (86% of which were Barn Owls) "were killed along embanked stretches of the highway that lacked roadside hedges and crossed open fields".

A1.13 Are traffic speed and traffic density both important?

Illner (1992) suggested that traffic speed is an important factor in road mortality and is often quoted in the literature. The suggestion by Illner that road death rates appeared to be little affected by traffic density is also quoted (for example, Massemin & Zorn 1998). However no studies have satisfactorily quantified both speed and density and looked for a relationship with mortality.

Considering speed alone, if one vehicle travels up an empty motorway, as its speed increases its hitting-power and turbulence increase, its element of surprise increases, its detectability and avoidability probably decrease. As its speed increases so do the chances of it killing, but, the faster it goes the shorter its journey time, therefore it is a danger for less time. A vehicle going half the speed would probably be capable of killing and would be a danger for twice as long. Therefore the relationship between speed and kill-risk is probably not linear.

Shawyer and Dixon (1999) found that the frequency of live sighting of birds seen by drivers on a major road was inversely related to traffic density and suggested that the noise of high-density traffic interfered with the birds' hunting.

Considering density alone, a fleet of vehicles travels up a motorway with gaps of 500 metres between them. The leader maintains a constant speed of 100 km/h but all the others go 105 km/h. The further they go the smaller the gaps between them. As the gap reduces, the element of surprise reduces, the detectability and avoidability of the fleet probably increase and the hunting-noise interference increases. Therefore the kill-chance probably decreases. But the more individual vehicles there are, the greater the chance that a bird flying over the road surface will be hit. Therefore the relationship between density and kill-risk is probably not linear either.

When traffic density reaches very high levels, speed decreases. The relationship between speed, density and theoretical kill-risk may be very complex and the relationship to owl mortality even more so. In summary, the possible influences of traffic speed and traffic density on owl mortality should not be over simplified.

A1.14 What about vehicle height?

As with many other factors, there is a lack of information on the possible effect of vehicle height. Barn Owls generally fly low, but the heights quoted show variation between authors and there appears to be no specific research into this aspect of behaviour.

Baudvin (1986) stated that Barn Owls fly at 2-5 metres above ground level and De Bruijin (1994) gave a figure of 1-3 metres for hunting flights. Taylor (1994) identified two different hunting methods. Perch-hunting Barn Owls normally left the perch and hovered for a short period at a height of about 3-4 metres before making an attack, sometimes hovering at about 2 metres before the final pounce. Flight-hunting Barn Owls flew lower at a height of 1-3 metres and the maximum height for accurate audio prey detection was 3 to 4 metres (Taylor 1994).

Barn Owl flight-height is most often quoted between 1 and 4 metres. Most modern cars are much less than two metres high, which suggests that taller vehicles may be more dangerous. Using circumstantial evidence, Shawyer & Dixon (1999) concluded that a significant number of casualties were the result of the turbulence generated by high-sided vehicles. Eye-witness accounts include birds struck by trucks and coaches (Taylor 1994) and by cars (Illner 1992). Cars may be important simply because they are more numerous.

A1.15 Can Barn Owls learn to avoid hazards such as moving vehicles or major roads?

Some authors have suggested that Barn Owls involved in collisions with vehicles died through inexperience (for example, Bunn et al. 1982). The fact that most road casualties are young birds (see A1.5) may seem to support this view, although the reasons for this have not been investigated. Massemin et al. (1998) suggested that more young birds die because they move more than adults, thereby increasing the risk of accidents. There is no actual evidence that inexperience is a contributory factor.

Considering lightweight individuals, Taylor (1994) stated "they may have been forced, through lack of alternatives, to feed in situations where they were more vulnerable, such as along road verges". This implies that Barn Owls may have some awareness of the dangers of hunting road verges and may intentionally avoid doing so. In support of this view, Taylor stated "several of the birds we radio tracked in Scotland had wide grass verges along quiet minor roads adjacent to their nest sites……..[in spite of the] high densities of voles and shrews, we never saw the birds hunt these areas." It should be noted that the birds in question were sedentary nesting adults and the roads were minor, with only occasional slow vehicles. In this situation vehicles were probably much less dangerous and the birds more likely to have survived close encounters with them. Therefore they may indeed have learned to avoid the road verges. A situation where young birds in post-natal dispersal arrive at a highly dangerous major road is entirely different. Such individuals may have no concept of the danger and therefore no desire to avoid major roads.

A1.16 Are road casualties weak birds that would have died anyway?

A sample of road killed Barn Owls was examined in south-west Scotland and their average weight was about halfway between those of healthy live birds and of birds that had died of starvation (Taylor 1993). In an American study, the weights of Barn Owls in three categories were compared: starved (n=54), trauma (mostly road kills) (n=21) and live healthy birds (n=162). The trauma victims were in better condition than the starved birds, with significantly more fat reserve, but were in poorer condition than live healthy birds. This may appear to suggest that road victims were in poorer condition. However, the dead birds were collected during a period of exceptionally cold winter weather, with an extreme low of –29°C, whereas the live weights were measured during a range of weather conditions (Marti & Wagner 1985).

Within a major British study into the causes of Barn Owl population trends, Percival (1990) compared the mortality of wild and captive-released Barn Owls and stated "The recorded cause of mortality of ringed birds recovered dead further emphasizes the poor fitness of captive-released birds. A much greater proportion of first-years was <u>killed by traffic, as might be expected if they were in weaker condition</u> or released into poorer habitats." The idea that there may be a relationship between condition and "accidental" death was also suggested by Newton et al. (1991), who stated "Poor condition may pre-dispose Barn Owls to accidents if it (a) leads them to spend more total time hunting, (b) leads them to spend relatively more time hunting in places where accidents are likely such as road verges, or (c) makes them less able to avoid collisions. For such birds accidents are the secondary rather than the primary cause of death".

However, amongst 627 Barn Owl carcasses submitted for post-mortem analysis, of which at least 42% were road victims, only 4% were starved as well as injured (Newton et al. 1991). Considering a larger sample of Barn Owl carcasses (n=1,101) Newton et al. (1997) stated, "most accident victims were of normal weight, so would presumably have lived considerably longer without the accident".

During an investigation into the ecology and conservation of Barn Owls in The Netherlands, 37 road casualties were recorded and generally showed no starvation weights (De Bruijn 1994). In France, the body condition of Barn Owls killed on motorways was investigated based on a sample of 127 intact road casualties. With the exception of mature females, the road casualties were in good body condition, which "does not support the idea that only birds in poor body condition were killed" (Massemin et al. 1998).

In a sample of fresh road casualties collected during frequent intensive searches of the A303 (Shawyer & Dixon 1999), 94% were judged to be in average or above average condition based on a combination of subcutaneous and pectoral muscle fat levels. In another sample resulting from much less frequent searches, 77% were in good condition. In both samples less than 15% of birds demonstrated lower than average weights (Shawyer & Dixon 1999).

Road casualty corpses are subject to dehydration after death, thus reducing their recorded weights. Although this factor is acknowledged by Newton et al. (1997), no researchers have quantified its effect nor compensated for it.

Within the report, other topics are reviewed as follows:

Chapter 2 The effect of a new major road on an existing local Barn Owl population
Chapter 3 The long-term effect of the presence of a major road on local Barn Owl distribution
Chapter 8 The distances traveled by Barn Owls generally and by road casualties in particular
Chapter 9 The extent to which roads act as barriers to Barn Owl dispersal
Chapter 10 The distance from major roads at which Barn Owls should be encouraged to nest

Appendix 2

Measures for the prevention or mitigation of Barn Owl road deaths – a literature review

A2.1 Can Barn Owl road deaths be mitigated?

In the context of road schemes, wildlife mitigation means measures to reduce adverse impacts on wildlife. In the case of Barn Owls, obvious mitigation measures would be: (1) the creation of obstacles that would force birds to fly higher whilst crossing the carriageway and (2) reducing the availability of small mammals in the road verges*. However, it is evident that road verge designers or managers have not adopted such measures. To some extent this may be a result of the omission of such measures from guidance documents, such as *Roads and nature conservation – guidance on impacts, mitigation and enhancement* (Anderson 1994) and *The significance of secondary effects from roads and road transport on nature conservation* (Markham 1996). Both reports included chapters on mitigation, but concentrated mainly on mammals and did not include the obvious measures for Barn Owls. In addition, the *Good practice guide for road schemes – biodiversity impact,* produced by a range of conservation agencies, did not include the obvious measures for Barn Owls in a checklist of mitigation measures (Byron 2000).

* A possible third mitigation measure would be the creation of prey-rich foraging areas away from dangerous roads. Although highly desirable in conservation terms, this is beyond the scope of the Highways Agency.

The government of The Netherlands is committed to minimizing the negative impact of its motorways (>2,100 km) and in 1995 published "*Natuur over Wegen*" (Nature across Motorways) for the international symposium "Habitat Fragmentation and Infrastructure" (Rijkswaterstaat 1995). The publication acknowledged that Dutch Barn Owl numbers had fallen as a result of motorway traffic and classed the Barn Owl as both the most rare and the most susceptible species. However, although mitigation measures for a wide range of species were described, there was little mention of mitigation for birds. 37 photographs of Dutch motorways were shown and every one depicted open areas of small mammal habitat adjacent to the road surface. Dutch motorway verges were managed to maximise their biodiversity and, on balance, were considered to be of significant positive benefit to wildlife (Rijkswaterstaat 1995).

In Britain, the Highways Agency published a study looking specifically at birds: *Highways and Birds – a best practice guide* (Hill 2001). It recommended that tree/hedge/scrub plantings should be kept 15-25 metres away from the highway edge, a distance which would allow ample space for Barn Owls to fly low before crossing the highway. It also recommended mowing the grass verge between the plantings and the highway in order to discourage small mammals, but qualified this by stating that there may be a negative effect on small mammals and raptors and identifying further research needed (Hill 2001). The author also identified a lack of research that quantified the effects of different road designs on bird populations generally, but nevertheless recommended the removal of scrub/hedges adjacent to roads for the benefit of Woodpigeon (*Columba palumbus*), Turtle Dove (*Streptopelia turtur*), Little Owl (*Athene noctua*) and Sparrowhawk (*Accipiter nisus*) – a measure which would probably increase the danger for Barn Owls.

In summary, Barn Owl road deaths can probably be reduced but government has not implemented appropriate mitigation measures and there has been a lack of appropriate guidance.

A2.2 Prospects for potential mitigation measures for Barn Owls

Due to the loss of wildlife habitat on farmland (see 1. 2. 1) road verges have become increasingly important wildlife habitats (Spellerberg & Gaywood, 1993). The amount of road verge in Britain has been estimated at between 200,000 and 212,220 Ha and has been described as Britain's largest nature reserve (Way 1977; Young 1991). Some verges have even been classified as Sites of Special Scientific Interest or designated as local nature reserves (ERM 1996). It has been suggested that the presence of small mammals on road verges may be more beneficial to some predator populations than the resulting losses through road mortality (for example, Garland 2002). Some authors have even suggested that small mammals should be positively encouraged to live in road verges and that hunting perches should be provided (Meunier *et al*. 1999; Meunier *et al*. 2000; Williams & Colson 1989). However, there is a lack of information which quantifies the effects of different road designs, landscape features, plantings and layouts, on bird populations (Hill, 2001).

Grass mowing to minimise small mammal populations

The Highways Agency has considered reducing small mammal abundance by mowing areas of rough grass in order to reduce the casualty numbers of Barn Owls (Garland 2002). The further research referred to by Hill (2001) was carried out by Garland (2002), who looked specifically at the ecology of small mammals on grassy road verges. Garland also investigated the factors that influenced the location of Barn Owl road casualties and whether verge mowing was effective in reducing small mammal abundance, thereby deterring birds of prey. The mowing regime consisted of only one cut per year on most trial plots. Even where verges were cut to an average height of 0.18m, autumn field vole abundance fell by less than 42% and wood mouse abundance actually increased by 14%. In addition, the reduced height of the sward probably increased the availability of the remaining small mammals to aerial predators. Unfortunately, Garland combined a doubtful suggestion that Barn Owls avoid grassland for three years following mowing, with a misinterpretation of Taylor (1994) and suggested that Barn Owls might avoid mown grass verges which contain a relatively high number of juvenile field voles. Garland observed that the mowing of verges in certain places might not reduce mortality as the birds may move further up the road to an uncut area. The possible effectiveness of more frequent or shorter mowing was not investigated and Garland considered that it would not be economically feasible, or desirable in conservation and landscape terms, to regularly mow long sections of road verge (Garland 2002).

Planting of dense shrubs to prevent access to small mammals by aerial predators

Baudvin (1997) and Muller & Berthoud (1997) suggested that road verges should be planted with dense shrubs to hide small mammals from birds of prey, encouraging them to hunt elsewhere. There can be little doubt that this would discourage Barn Owls from hunting road verges. However, the management of vegetation to discourage animal presence on roads usually focuses on reducing roadside cover (Singleton & Lehmkuhl 2000). The use of berry-producing shrubs may increase passerine mortality (Hill 2001) and the planting of any kind of trees or shrubs may encourage deer unless extensive fencing is also provided. In addition, the many plant, invertebrate and vertebrate species associated with open grassland may be negatively affected and this may, on balance, be generally unacceptable.

The creation of obstacles which force birds to fly higher across roads

Barn Owl road deaths are less frequent in situations where they are forced to fly higher. For example, fewer casualties are found on sunken road sections as opposed to level or raised sections (Massemin & Zorn 1998; Shawyer & Dixon 1999). The presence of roadside hedges also appears to reduce mortality (Massemin & Zorn 1998; Garland 2002). In The Netherlands, trees have been allowed to grow adjacent to roads in some places to force birds to fly higher when approaching the road (Rijkswaterstaat 1995). However, small isolated clumps of trees are unlikely to be effective.

Several authors, including Toms (1996) and Shawyer & Dixon (1999), have recommended lines of dense trees/shrubs planted on earth banks adjacent to roads. Garland (2002) recommended the establishment of thick hedgerows 4m in height, especially where wildlife corridors intersected with road verges. The establishment of such obstacles along great lengths of major road has not been previously recommended. The Highways Agency Report *Highways and birds* (Hill 2001) stated that hedgerows should be set back from the road, scrub should be at least 25 metres from the road and that tree cover close to the carriageway should be avoided. The use of trees for forcing birds to fly higher was recommended as having "limited application" and plantings should be more than 50m from the carriageway (Hill 2001), a distance which would allow Barn Owls plenty of space to swoop low before crossing the carriageway.

The creation of continuous low flight obstructions that force birds to fly higher whilst crossing roads is almost certainly the most effective mitigation possible. If Barn Owls were unable to fly across roads within vehicle heights they would not be killed irrespective of food availability, how often they visited the roadway, the number of vehicles, traffic speed etc.

Encouraging Barn Owls to continue using major road verges

Shawyer & Dixon (1999) suggested that Barn Owls were forced to fly over the road surface where areas of scrub/trees interrupted their flight path along rough grass verges. In order to reduce this suggested effect, "*a swathe of grassland not less than 3m wide should be cut through the center of these existing 'barriers' to maintain safe flightpaths in an attempt to discourage Barn Owls from moving off the verge and into the road*" (Shawyer & Dixon 1999). The suggestion was also made that additional corridors of prey-rich grassland should be provided running parallel to the road at a distance of 100m or more. These two suggestions were repeated by Garland (2002). Shawyer & Dixon (1999) also suggested positively encouraging Barn Owls to make additional use of these areas by the provision of nestboxes. The idea was that Barn Owls could forage major road verges and the additional corridors of rough grassland and nest in the boxes, so successfully that their survival and productivity outweighed the effect of road mortality, thereby creating self-sustaining Barn Owl populations along Britain's major roads.

However, this idea could only work if individual Barn Owls were able to forage major road verges and surrounding land for long enough to breed without becoming road casualties. In addition, their offspring would need to be able to disperse from the nestboxes without an excessively high proportion becoming road casualties. The idea is based on untested assumptions. Evidence presented in Chapters 1, 2, 6, 8, 9 and 10 suggests that it would not work. It is probable that any increase in Barn Owl activity along major roads would result in a corresponding increase in mortality. If the new rough grass corridors and nesting boxes were provided at a much greater distance from major roads (for example, over 3 km) it would be much more likely to be beneficial (see Descriptive Summary). However, the implementation of such a scheme is well beyond the scope of the Highways Agency.

Barn Owl mitigation – a summary

There are two basic approaches: (a) to discourage Barn Owls from major roads by reducing prey availability in the verges and creating roadside hedges, over great distances, to force birds to fly higher and (b) to encourage the greater and <u>perhaps</u> safer, use of major road verges by Barn Owls in the hope that any increase in mortality would be offset by an increased population size.

In spite of acknowledging that the Barn Owl was the rarest species affected by motorways, the most susceptible to the fragmentation effect and that motorways had caused a drastic decline in numbers in some areas, the Dutch government took the view that, overall, the existence of motorway verges was good for wildlife (Rijkswaterstaat 1995). Garland (2002) also acknowledged the importance of verges for wildlife and suggested that small mammal populations should be positively encouraged. Mitigation, he suggested, should concentrate on improving the safety of Barn Owls hunting road verges and not aimed at deterring them.

In summary, approach (a) may be contra-indicated on grounds of conservation, landscape amenity, traffic safety, practicality and cost. Approach (b) would almost certainly fail through increased Barn Owl road mortality.

In the creation of the recommendations contained within this report (see Executive Summary and Recommendations), numerous and often conflicting factors were carefully considered (see Descriptive Summary).

A2.3 Highways Agency - Biodiversity Action Plan (HABAP)

The Highways Agency is currently responsible for 10,400 km of major roads across England, which includes the management of major road verges amounting to 30,000 hectares (HA 2002). In 2000 the Highways Agency stated its target to manage the core HA road network "in line with Biodiversity Action Plans". The HABAP, published in 2001, contained a range of detailed plans for 5 priority habitats, including grassland and 20 priority species, including the Barn Owl. Targets for positive conservation action by the Agency included numerous wildlife habitat creation schemes.

Grasslands occupy a large proportion of the Highways Agency's "soft estate" (major road verges) and the majority of valuable areas are classed as species-rich neutral grassland. Within the Plan, the HA's stated objectives included the protection, maintenance, enhancement and *creation* (author's emphasis) of valuable grassland habitats. For some species associated with grass land, such as Primrose *Primula vulgaris* and Cowslip *Primula veris*, recommended grass cutting every 1-3 years would be beneficial for small mammals.

Five Species Action Plans (SAPs) were published covering priority species associated with grassland road verge. Three were for scarce species and the planned mitigation/management actions related only to small numbers of sites in specific localities. There were only two SAPs relating to grassland road verge management across the network, one for Red Kite/Buzzard/Kestrel and one for Barn Owl.

The SAP for Red Kite/Buzzard/Kestrel included the "enhancement" of habitat, both across specific regions and across the entire network. The effect of grass verge management on Kestrels, which hunt extensively for small mammals on road verges, was identified as an issue. "Best practice" was to be employed in the management of road verges across the network to enhance habitat for Kestrels (HA 2002). In other words, for the benefit of Kestrels and to a lesser extent, Red Kites and Buzzards, road verges would be managed to maximise the availability of small mammals. This would result in a continuation of the suitability of road verges for Barn Owl foraging and perhaps even an increase.

The HA Barn Owl Species Action Plan acknowledged the extent of Barn Owl decline and the fact that "*increased road construction is estimated to have led to a doubling of Barn Owl roads deaths since the 1950s, to between 3,000 and 5,000 deaths per year*". The plan aimed to "*reduce the level of incidental mortality whilst ensuring favorable management of Barn Owl habitat*". The extent to which these two aims are mutually exclusive was not mentioned. Under "current HA initiatives", the HABAP stated that "*it would clearly be counter-productive to carry out management that would encourage certain BAP species onto road verges, if these species are likely to suffer high rates of mortality as a direct result of the close proximity of the carriageway*" but in the Barn Owl SAP they planned to "*provide detailed information on the management of verges for the benefit of Barn Owls*". To the Agency's credit they also planned to "*minimise situations which lead to mortality*" and "*identify worst sites for road casualties and implement appropriate action*". The "*mitigation of fragmentation*" by "*maintaining green links across roads*" would be "*considered*".

The nebulous nature of these statements reflected the fact that, at the time of writing, the Highways agency did not know what they should do about Barn Owl road mortality. In spite of this, they had decided positively to manage verges for the benefit of Kestrels and other species, which suggested that they would not tackle the Barn Owl problem by reducing the attractiveness of road verges. It is difficult to see how the creation of "*green links*" across roads could benefit Barn Owls across Britain. The "*appropriate actions*" at mortality black spots were not identified.

The Barn Owl Trust was identified as the potential partner in all of the above actions, which suggests that the Highways Agency was looking to the Trust for guidance. Action 7 stated "*liaise with the Barn Owl Trust regarding their report on the impacts of traffic on Barn Owls and implement appropriate actions*".

The Trust's recommendations to the Highways Agency are given within the Executive Summary.

Appendix 3

Terminology, definitions and abbreviations used

Major roads / trunk roads (collective terms)
Motorway, dual carriageway, or modern A road, built for fast traffic with verges and or embankments which provide a wildlife habitat.

Minor roads (collective term)
Country lane, traditional A and B roads.

Country lanes
Single lane roads without A or B classification, normally with hedges both sides, suited to low speed traffic.

Traditional A/B roads
Two lane roads, normally with hedges both sides, generally suited to low speed traffic, but with some long straight sections suited to medium speed traffic.

Modern A roads
Two or three lane roads with long straight sections built for fast traffic, with verges and/or embankments which provide a wildlife habitat.

Dual carriageways
Two lanes in each direction (four lanes in total), sometimes with a central reservation, built for fast traffic with verges and/or embankments which provide a wildlife habitat.

Motorways
Roads with three lanes and a hard shoulder in each direction (eight lanes in total), sometimes with a central reservation, built for fast traffic, with verges and/or embankments which provide a wildlife habitat.

BO
Barn Owl (*Tyto alba alba*)

BOT
Barn Owl Trust

BTO
British Trust for Ornithology

HA
Highways Agency

BAP
Biodiversity Action Plan

DCC
Devon County Council

DTI
Department of Trade and Industry

DOE
Department of the Environment

EIA
Environmental Impact Assesment

HABAP
Highways Agency Biodiversity Action Plan

MRTA
Major Road Traffic Accident

RTA
Road Traffic Accident

SAP
Species Action Plan

CER
Calculated Encounter Rate