2 Conservation

https://doi.org/10.1017/9781316694114.004 Published online by Cambridge University Press

Forests are destroyed worldwide, as here in Tasmania. © Michael Todd.

2.1 WHY PROTECT BARN OWLS?

It's never too late to repair the irreparable

Although ornithologists are motivated by an urgent need to protect nature, we need to convince society as a whole. Why invest money and human resources in nature conservation? Why preserve barn owls?

The anthropocentrism philosophy considers the rise of humans as the dominant species on earth to be justifiable. Three arguments are presented: (1) Human supremacy over all other organisms is the wish of a superior force (God), and we are the vehicle of this divine intervention; (2) Our intellectual superiority gives us the right to dominate all other inferior organisms; and (3) Humans have faced natural selection over thousands of years, as have other organisms; thus, humans rule the world as dinosaurs did millions of years ago, and so what? The negative impact of humanity on the environment may therefore appear 'natural' or legitimate, as long as it is useful to mankind. The paradox, however, is that what is useful today might be disastrous tomorrow.

While deforestation provides wood and space to cultivate fields, excessive tree-cover loss has severe impacts on ecosystem services including the depletion of water resources, decreased resorption of CO_2 and soil degradation, not to mention the loss of biodiversity. Another example is the use of DDT: this chemical kills insects to increase plant production but eradicates the beneficial insects that pollinate these plants. A scientific solution would be to produce genetically modified pollinators that resist insecticides; but this approach may have unintended negative impacts. Science is capable of developing short-term, often complex and clever solutions, but scientists often do not appreciate

https://doi.org/10.1017/9781316694114.004 Published online by Cambridge University Press

Food chain: a barn owl holding a wood mouse in its bill, while the rodent has an ear of corn. Photo taken with a camera trap in Switzerland. © Robin Séchaud & Kim Schalcher

or investigate the full societal and ecological ramifications of these solutions, and the long-term impacts may even be impossible to predict.

An economic model that engenders greed and the over-exploitation of natural resources, favouring economic growth, can indeed generate gains in the short term, but we can predict the depletion of natural resources and the extinction of biodiversity stemming from our current economic obsession. Before the multitudes of species in the wild have disappeared, with only a few individuals left roaming in dedicated sanctuaries and zoos, the point of no return will have been reached. Biodiversity provides humans with high-quality resources and the healthy environment we depend upon. Successful coexistence with other species will be a testament to our ability to live sustainably, within ecological bounds. It is therefore our duty to protect nature.

Ecological function of the urban perspective Most humans live in cities, disconnected from both the natural environment in which our species initially evolved, and the habitats society depends on. Most people do not even consider how water arrives at their taps, as if easy access to water is the normal state of affairs. Most humans wonder 'why should we protect nature?' – and if they gave it a moment's thought they might also ask 'why in particular should we protect the barn owl?' The answer is that top predators such as the barn owl stabilize ecosystems by structuring lower trophic levels. In North America, the reintroduction of wolves has balanced deer populations and, in turn, forest growth and composition. In Europe, wild boars, which cause problems for agriculture, thrive because their natural predators, such as wolves, are killed. Biodiversity can also be preserved simply to meet our need for knowledge, but conservation is synonymous with our ability to live within limits – and ultimately with our survival.

For biologists seeking to implement effective conservation measures, the acquisition of detailed knowledge is the necessary first step. However, when faced with applications for the use of public

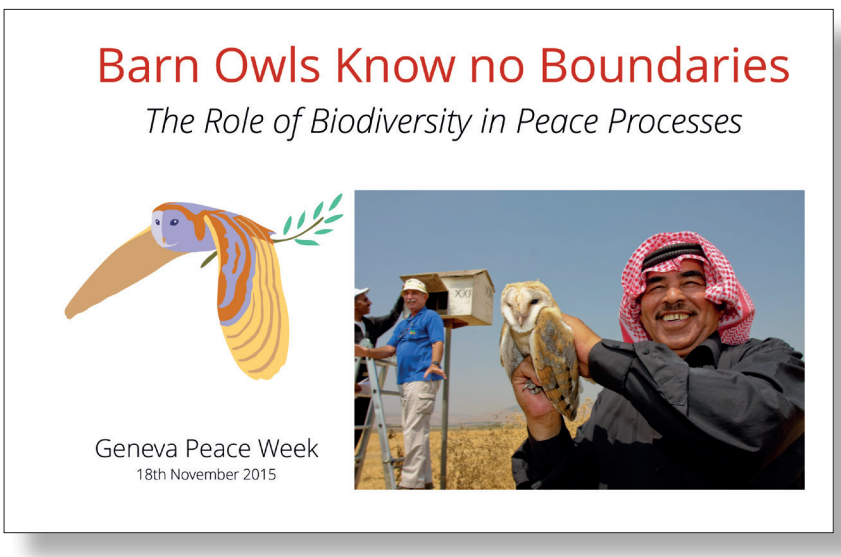
https://doi.org/10.1017/9781316694114.004 Published online by Cambridge University Press

money for conservation research, urbanites are often unsupportive and further arguments are needed. Watching a good TV programme on animals may be sufficient to engender the feeling that 'we love nature' provided we do not have to participate directly or indirectly in nature conservation. For some, nature may have an aesthetic or ludic value: forests are used for relaxing, and a cliff is merely a place to perform extreme sports, such as climbing or BASE jumping. Of course, nature is much more than this and does not belong to humans simply for recreational, or any other, purposes.

Owls for peace At least ten million species live on earth. Thus, why should we care about the barn owl specifically?

This bird fascinates us, stimulates our imagination, yet scares us and is tied to myths which have existed for millennia. Stories of the barn owl's natural history generate empathy for the catastrophic impact of global changes caused by human activities. For countless years, nature has inspired human development in science, fashion, the arts and many other fields. The barn owl is no exception, having led to developments in the fields of aeronautics, neuroscience and biomedicine. This species is also an ideal subject for education, particularly to increase awareness of the ecological importance of protecting nature. The bones of the barn owl's prey are exceptionally well preserved in pellets, providing a unique opportunity to study predator–prey interactions through a fun pellet dissection!

The barn owl can even act as a gateway to peace. Barn owls have brought members of the Israeli, Palestinian and Jordanian communities to the same table. In this zone of intense conflict, people-to-people interactions are necessary to maintain the dialogue between war-torn communities. In the Middle East, as in many other regions, farmers spread substantial quantities of rodenticides to kill the voles and mice that devastate their crops. After numerous discussions, meetings and conferences, farmers have chosen to favour barn owls as biological pest control agents instead of using copious amounts of rodenticides. This represents a cultural shift, and a huge success, given that many farmers previously believed the barn owl to be a bad omen. What is bringing Israeli, Palestinian and Jordanian farmers to sit around the same table is a shared common problem, namely the issue of



The barn owl is a flagship species for nature conservation. A project using barn owls as biological pest control agents in the Middle East was presented at 'Geneva Peace Week' on 18 November 2015 at the House of Peace at the Geneva Centre for Security Policy. This conference emphasized the role played by nature conservation in the reconciliation between Israelis, Palestinians and Jordanians.

https://doi.org/10.1017/9781316694114.004 Published online by Cambridge University Press

agricultural pests, and the need to find a solution that is both economical and ecological. This is an issue that 'knows no boundaries', given that mice and owls certainly do not respect artificial human political borders. This approach successfully brings people together because it avoids the sensitive topics, such as culture, tradition and religion, that are at the root of the conflict, and instead provides common ground for dialogue.

In summary, the barn owl has all the qualities to be considered a flagship species for nature conservation as a whole, and may even become a symbol of peace. In this sense, the human–barn owl relationship embodies what Bobby McLeod, an Aboriginal activist and poet said – '*To heal ourselves we must heal our planet, and to heal our planet we must heal ourselves.*'

FURTHER READING

Roulin, A., Mansour, A. R., Spiegel, B., Dreiss, A. N. and Leshem, Y. 2017. 'Nature knows no boundaries': the role of nature conservation in peacebuilding. *Trends Ecol. Evol.* **32**: 305–310.

Sergio, F., Schmitz, O. J., Krebs, C. J., Holt, R. D., Heithaus, M. R., Wirsing, A. J., Ripple, A. J., Ritchie, E., Ainley, D., Oro, D., Jhala, Y., Hiraldo, F. and Korpimäki, E. 2014. Towards a cohesive, holistic view of top predation: a definition, synthesis and perspective. *Oikos* **123**: 1234–1243.

Smith, D. W., Peterson, R. O. and Houston, D. B. 2003. Yellowstone after wolves. *BioScience* **53**: 330–340.

https://doi.org/10.1017/9781316694114.004 Published online by Cambridge University Press

Scientific studies often require the capture and manipulation of wild barn owls.

2.2 ETHICS

The end does not necessarily justify the means

Implementing effective nature conservation measures requires that we observe animals in their natural habitat. However, the mere presence of ornithologists can sometimes represent an intrusion into the daily lives of animals. Often, we face the paradox that protecting what we love may require disturbing it. How do we resolve this?

Working with animals bestows upon us the duty to adopt an ethical approach. This is a complex problem because we must reconcile the need to gather scientific data to promote nature conservation with the need to avoid disturbing animals. Certain people believe that as long as animal populations are not jeopardized by scientific observations, human interference can be tolerated even if it negatively affects some individuals. Others claim that the act of capturing one animal for scientific purposes is an intolerable intrusion.

Assuming that animals do not suffer in any measurable way because of scientific work, and assuming that reproductive success is not penalized by that work, it can be difficult to define what 'disturbance'

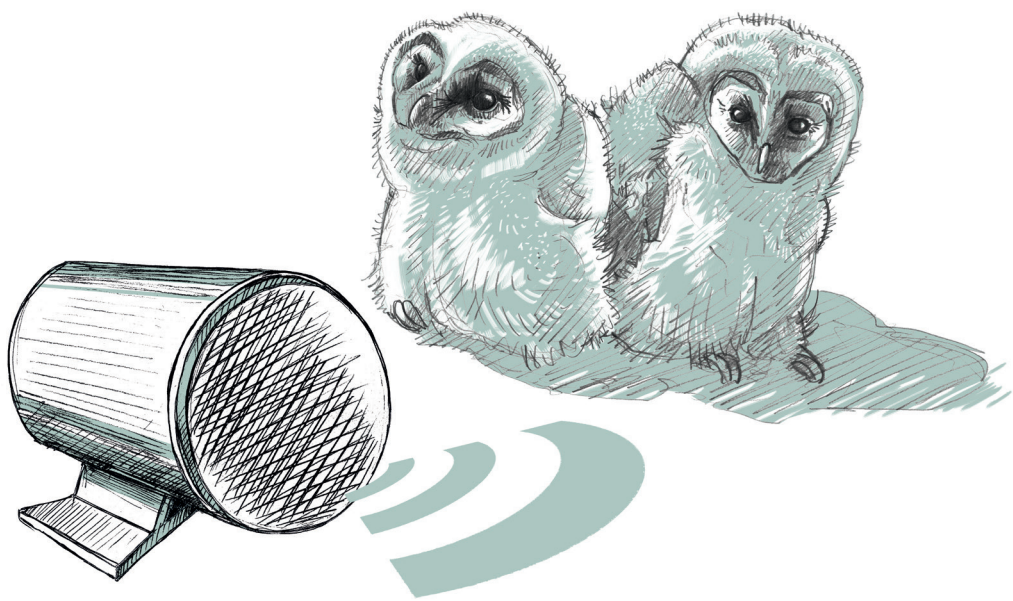
https://doi.org/10.1017/9781316694114.004 Published online by Cambridge University Press

means without introducing psychological terms. Most often researchers are careful to minimize their impact, to ensure that individuals suffer no long-term effects, and that their reproductive success is not penalized. However, given the difficulty in assessing disturbance, and even defining what we mean by disturbance, it is hard to understand the extent to which ecologists might be affecting individuals.

Experimental approach Science uses different approaches to answer questions about animal behaviour and ecology. The most controversial approach is the **experimental method**, in which animals are manipulated. Experimentation is not the only way biologists answer questions about the natural world, but it is a tool that is used by many ecologists. The logic of **experimental design** is to manipulate a factor in order to measure its effect independently of any other variables. With everything else being equal, the only thing that distinguishes individuals in a study is the experimental treatment.

For instance, to determine whether barn owl parents adjust the number of prey items brought per night per offspring in relation to brood size, we can experimentally manipulate brood size. To decouple habitat quality from the parental ability to modify feeding rate in relation to family size, we can exchange a different number of hatchlings between randomly chosen nests. For instance, two hatchlings from nest A are put in nest B and one hatchling from nest B is put in nest A. If we replicate this exchange of two nestlings with one nestling between many pairs of nests, we will have a representative sample of nests for which brood size has been experimentally enlarged or reduced by one nestling. Even if parents initially intended to raise a given number of nestlings, we force them to take care of one extra or one fewer chick. This experimental design is feasible in birds because parents are usually unable to identify their progeny. A couple of weeks later, we can measure parental feeding rate, with the prediction that parents tending an experimentally reduced brood will bring more food items per night per nestling than will parents tending an experimentally enlarged brood.

Why is it not enough to measure parental feeding rates in relation to brood size in non-manipulated nests? Simply because it is difficult to propose *a priori* predictions in a non-experimental set-up. Each nestling may be fed at a lower rate in larger broods because food resources are limited and must be shared among more mouths. Alternatively, each nestling may receive more food items in larger



Negotiation calls are broadcast to two barn owl siblings in a so-called 'playback experiment'.

https://doi.org/10.1017/9781316694114.004 Published online by Cambridge University Press

broods if stronger parents or parents living in better habitats are able to produce larger broods. These parents could raise more offspring and simultaneously feed all of them at a higher rate than could weaker parents living in poor environments.

To the lay public, the word 'experiment' is often associated with cruel treatments inflicted on animals. However, for the evolutionary ecologist seeking to understand why certain physiological, morphological or behavioural traits evolved in a particular environment, experimental design must remain within the natural range of variation for the variable of interest. Thus, creating experimental broods containing sixteen chicks when the maximal brood size in the wild is twelve makes no sense. Observing that parents tending sixteen nestlings feed each chick at a lower rate than do those tending five-chick broods tells us nothing about whether parents increase hunting effort for their offspring at the expense of self-feeding. Experiments should always place the species in a realistic context that is no more 'cruel' than the situation that they experience daily.

Implementing appropriate experimental designs is not trivial. In the 'brood-size manipulation experiment' above, we must allocate different brood sizes randomly across parents and habitats, because it is likely that stronger parents produce more chicks. Thus, if we want to measure the effect of brood size independently of other variables, strong and weak parents across habitats of varying quality should be given the opportunity to raise a similar number of chicks.

Carefully designed experiments can answer an almost endless variety of questions that fascinate the human mind. However, in the face of the current 'sixth mass extinction event' and the second 'scientists' warning to humanity', perhaps it is time to concentrate our minds on seeking answers that will bring the greatest benefit for conservation and environmental education.

Are scientific studies more useful to nature or to the scientists? Evolutionary ecologists often work with wild organisms outdoors. In doing so, they join a variety of different stakeholders, such as farmers, hunters and nature lovers, who also utilize the outdoors in one way or another. The usefulness of observations can sometimes be questioned, and consequently scientists can be perceived to be using the natural environment for their own career interests, rather than to ultimately help preserve nature. This is why it is so critical that, as researchers, we communicate effectively and justify our work to the lay public.

Biodiversity is under intense pressure and many species are disappearing. This motivates some researchers and practitioners to invest effort and money in conservation using a variety of complementary approaches. The first method is to carry out applied research aimed at devising effective measures to preserve habitats and species. Another approach is to determine the factors that are limiting survival, productivity and dispersal. Fundamental research that is *a priori* not directly related to conservation can also be important because it just might, sooner or later, provide a missing bit of knowledge that can be translated into conservation action, assuming that researchers interact with practitioners.

The present book aims to summarise the current knowledge about the barn owl, a flagship species, to spread the noble message of conservation. An intimate knowledge of animals can help motivate society to take active measures to protect animals. '*In the end we will conserve only what we love; we will love only what we understand; and we will understand only what we are taught*' (Baba Dioum, 1968).

Respectful methods To successfully spread the message that we must protect nature, scientific credibility and the use of respectful methods while studying barn owls are essential. Experienced fieldworkers usually know what can and cannot be done while working with wild barn owls and how to minimize disturbance. Some essential practices need to be emphasized:

- Barn owls are particularly sensitive to disturbance during the pre-laying and laying period. Visiting nest sites before eggs are laid can induce owls to abandon sites, especially individuals that are new or underweight. To avoid this situation, ornithologists should prospect potential sites at night without capturing them.

https://doi.org/10.1017/9781316694114.004 Published online by Cambridge University Press

Two Palestinian farmers holding a barn owl. © Hagai Aharon

- During incubation, owls can be sensitive to disturbance and abandon their clutch if captured, an effect that can differ between individuals and between populations.
- The ties between parents and offspring are stronger at the nestling stage than at the egg stage, and parents rarely abandon their young if disturbed. However, disturbance must still be kept to a minimum, as cases of human disturbance leading parents to stop caring for their brood have been observed, although primarily when the nestlings were very young.
- When parents are captured in the nest, care must be taken to ensure they do not fly away once they are placed back in it. An adult owl flying in daylight can be attacked by crows, and if the eggs and young are left unattended for a long period the nest can ultimately fail.
- Finally, the potentially negative impact of disturbing owls for the purpose of monitoring makes sense only if the research leads to implementation of effective conservation measures, and if ornithologists communicate their work.

https://doi.org/10.1017/9781316694114.004 Published online by Cambridge University Press

In the nineteenth century, farmsteads in the United Kingdom could host dozens of barn owls. This is unfortunately no longer the case.

2.3 DECREASES IN BARN OWL POPULATIONS

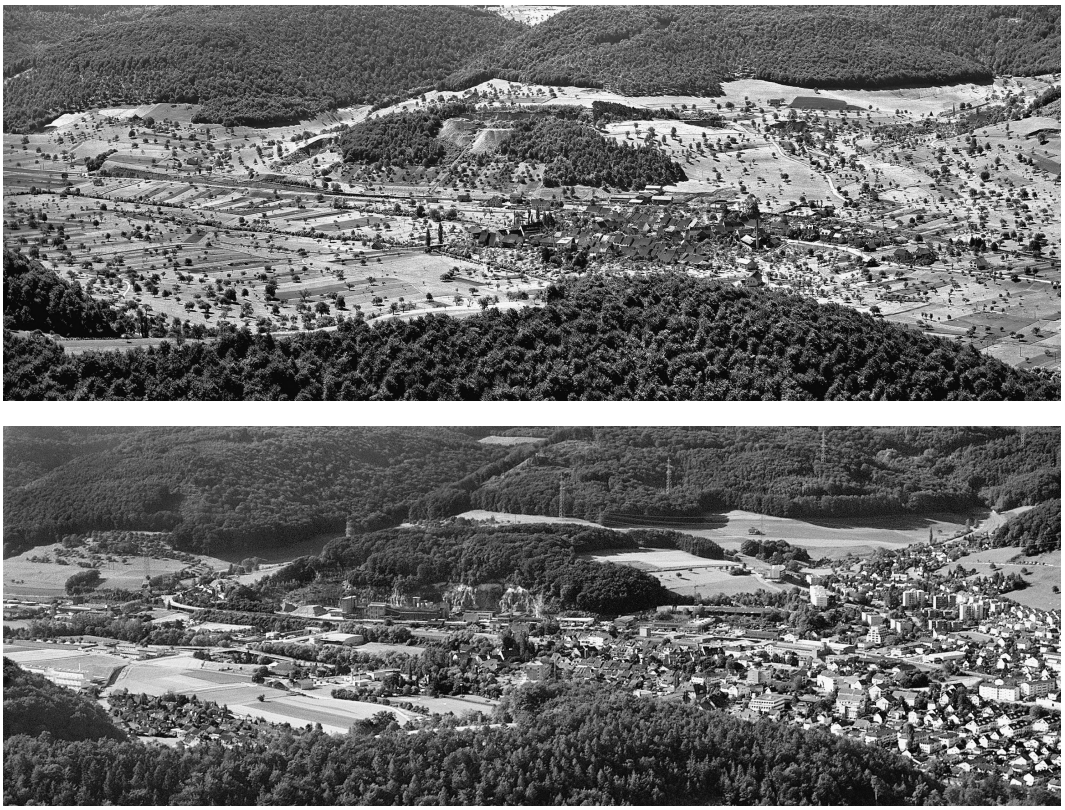
How many?

Monitoring bird populations is one of the most important activities of ornithologists, particularly when species are becoming endangered. Some historical trends in barn owl population sizes are known in Europe and to a lesser extent in North America and Australasia. Unfortunately, these numbers indicate strong declines. There are only a few areas where populations are showing a substantial increase thanks to local conservation action.

The arrival of European settlers in America in 1492 and in Australia in 1788 caused major ecosystem changes. In fact, in all 'developed' countries, nature has suffered profound habitat alteration and increased disturbance associated with human activities. Effects include increases in pollution, traffic, persecution, habitat degradation and intensification of agricultural practices.

Most cultures have a view on barn owls; in some they are considered a harbinger of evil or a source of black magic, in others they are used in traditional medicine, and in some they are even eaten! In 2008, a man was arrested in Malaysia for possessing 917 dead owls, of which 796 were barn owls, destined to be eaten in China. We certainly hope that such cases are one-offs and not indicative of an ongoing international trade. Ornithologists have worked hard to secure the legal protection of owls, something that was achieved only relatively recently worldwide (1954 in the United Kingdom, 1967 in Italy, 1971 in Australia, 1972 in the USA and Malaysia, 1973 in France).

https://doi.org/10.1017/9781316694114.004 Published online by Cambridge University Press



Two pictures taken at the exact same place near Basel, Switzerland, in 1904 (© K. Lüdin) and 1999 (© Karl Martin Tanner). From Tanner, K. M. 1999. *Augen-Blicke. Bilder zum Landschaftswandel im Baselbiet. Quellen und Forschungen zur Geschichte und Landeskunde des Kantons Basel-Landschaft*, Band 68, Verlag des Kantons Basel-Landschaft, Liestal.

In more recent times, there can be little doubt that habitat loss is a much bigger factor than direct persecution. The situation is particularly problematic for habitat specialists, such as the sooty owls and grass owls, which suffer from forest clearance and intense use of grasslands for agriculture respectively. These species very rarely or never use nest boxes, so providing nest boxes is not an applicable solution to help restore their populations. This is anyway not the long-term answer for any of the Tytonidae – or any other birds.

The number of barn owls has been estimated in Europe, where between 100 000 and 250 000 pairs are reported, with most individuals being located on the Iberian Peninsula. Historical changes in the sizes of European barn owl populations illustrate the critical situation of this bird in many countries. In the Netherlands, for example, 1800–3500 pairs were breeding before 1963, 230–490 from 1969 to 1974 and 300–500 pairs from 1982 to 1984. In England and Wales, landscape modification caused a huge decrease in the barn owl population. Approximately 12 000 pairs were breeding in 1932, 4500–9000 from 1968 to 1972 and only 4000 in 1995 to 1997 across the entire United Kingdom.

In North America, data on barn owl population size are restricted to the northern range of the barn owl's distribution. For example, in Ohio, the first barn owl was recorded around 1860 when humans started to clear forests, offering new foraging habitats to this bird. Populations peaked in 1931–1935, and as crop fields progressively replaced less intensive forms of production, barn owl numbers decreased. Similarly, in British Columbia, Canada, the first barn owl was recorded in 1909;

https://doi.org/10.1017/9781316694114.004 Published online by Cambridge University Press

the population reached 1000 pairs in 1983 and decreased to 250–500 pairs in 2008. Thus, owl populations can be both positively and negatively impacted by human activity.

Limited data are available for other continents. In Tasmania, the masked owl population decreased by a factor of two after human settlement. Because, like the grass owl, this owl very rarely breeds in nest boxes, preserving natural nest sites is even more crucial – as without them the owls are left with nowhere to breed. The situation in Malaysia is particularly interesting because it highlights the double-edged effect of human activities. Arriving from Java or Sumatra, barn owls started to breed in Malaysia at the end of the nineteenth century. Before 1968, there were few observations of breeding barn owls, but since the increase in rat numbers in newly established palm oil plantations, owls have been positively encouraged, through the provision of nest boxes, in order to control the rat population. Clearing rainforest for palm oil plantations causes immeasurable social and ecological damage, however, and the sudden increase in barn owls in no way compensates for the systematic destruction of biodiversity.

FURTHER READING

Altwegg, R., Roulin, A., Kestenholz, M. and Jenni, L. 2006. Demographic effects of extreme winter weather in the barn owl. *Oecologia* **149**: 44–51.

Bell, P. J. and Mooney, N. 2002. Distribution, habitat and abundance of masked owls (*Tyto novaehollandiae*) in Tasmania. In Newton, I., Kavanagh, R., Olsen, J. and Taylor, I. (eds) *Ecology and Conservation of Owls*. Melbourne: CSIRO, pp. 125–136.

Blaker, G. B. 1933. The barn owl in England. *Bird Notes and News* **15**: 207–211.

Bruijn, O. de. 1994. Population ecology and conservation of the barn owl *Tyto alba* in farmland habitats in Liemers and Achterhoek (the Netherlands). *Ardea* **82**: 1–109.

Colvin, B. A. 1985. Common barn-owl population decline in Ohio and the relationship to agricultural trends. *J. Field Ornithol.* **56**: 224–235.

Dadam, D., Barimore, C. J., Shawyer, C. R. and Leech, D. I. 2011. The BTO barn owl monitoring programme 2000–2009. *BTO Research Report* **557**.

Huang, A. C., Elliot, J., Martin, K. and Hindmarch, S. 2013. SARA-listed (Species At Risk Act) barn owls (*Tyto alba*) in British Columbia: genetic diversity, connectivity, and divergence. Worldwide Raptor Conference, October 2013, Bariloche, Argentina.

Huffeldt, N. P., Aggerholm, I. N., Brandtberg, N. H., Jorgensen, J. H., Dichmann, K. and Sunde, P. 2012. Compounding effects on nest-site dispersal of barn owls *Tyto alba*. *Bird Study* **59**: 175–181.

Lenton, G. M. 1984. Moult of Malayan barn owls *Tyto alba*. *Ibis* **126**: 188–197.

Shepherd, C. R. and Shepherd, L. A. 2009. An emerging Asian taste for owls? Enforcement agency seizes 1,236 owls and other wildlife in Malaysia. *BirdingASIA* **11**: 85–86.

Toms, M. P., Crick, H. Q. P. and Shawyer, C. R. 2001. The status of breeding barn owls *Tyto alba* in the United Kingdom 1995–97. *Bird Study* **48**: 23–37.

Williams, V. L., Cunningham, A. B., Kemp, A.C. and Bruyns, R. K. 2014. Risks to birds traded for African traditional medicine: a quantitative assessment. *PLoS One* **9**: e105397.

https://doi.org/10.1017/9781316694114.004 Published online by Cambridge University Press

Blue pellets containing acute rodenticides (1080 sodium fluoroacetate) at the entrance of a vole tunnel in Israel. © Motti Charter

2.4 POLLUTION

Pernicious human practices

Owls suffer from the human use of poisons and other pollutants, just as many other organisms do. Although the situation is worrying, the barn owl's situation offers some refreshing optimism. In many parts of the world, barn owls are no longer the target of intentional poisoning, and their appetite for small mammals means that they are even used as efficient biological pest control agents.

The by-products of industrial activity are found in the air, soil and water, contaminating nature. Barn owls are no exception. Brominated flame retardants used for plastics, textiles, insulation materials, electrical and electronic equipment are found in large quantities in Dutch barn owls. Polluted air affects not only city dwellers but owls as well. Polycyclic aromatic hydrocarbons are volatile compounds and, not surprisingly, strongly affect the owl lung, as has been found in Spain.

Owls are mainly contaminated through their food, and their position at the top of the food chain is highly problematic because of bioaccumulation: poisons accumulate in the predator's body following repeated consumption of contaminated prey. Pollutants such as aluminium, arsenic and lead are found in owl feathers and pellets, but unfortunately the production of these is not enough to detoxify the body entirely. We must continue to conduct eco-toxicological studies to raise awareness of the extent of contamination and the negative impact of toxic industrial and agricultural products. In the USA, the abundance of some pollutants, such as organochlorine pesticides (e.g. DDT) and polychlorinated biphenyls (PCBs), in barn owls' bodies decreased from 1975 to 1994, but the abundance of many other pollutants, such as anticoagulant rodenticides, increased.

https://doi.org/10.1017/9781316694114.004 Published online by Cambridge University Press

Anticoagulant rodenticides

Harm is inflicted on the environment by a broad suite of human activities from which few organisms profit. Although agriculture offers new food sources for some invertebrates, birds and small mammals, many of these ultimately contribute to crop loss and are considered as pests. The farmer's way of destroying these is chemical warfare: they respond to an evil with an evil!

The first generation of anticoagulant rodenticides was introduced in the 1940s, but small mammals rapidly developed resistance. A second-generation rodenticide, 100–1000 times more toxic, was then developed in the mid-1970s. The latter compounds typically concentrate in the liver of rats and mice, leading to haemorrhage. As poisoned rodents are mobile for up to 14 days before dying, the chemicals used to control rats and mice in and around buildings may also poison predators that forage in such places. By eating poisoned small mammals, predators accumulate rodenticides in their bodies, and some ultimately die. The control of pests that ends up killing their predators is ultimately counterproductive. The snake bites its own tail!

Researchers have found rodenticide residues in predatory bird carcasses in many countries, including Canada, the Canary Islands, Denmark, France, Hungary, Spain and the United Kingdom. In some studies, barn owls are less contaminated than other bird species. In Scotland, for example, anticoagulant residues were detected in 35% of dead barn owls compared with 69% of dead red kites and 54% of dead sparrowhawks, and in Canada they were detected in 62% of dead barn owls compared with 92% of dead barred owls. However, results from the United Kingdom's Predatory Bird Monitoring Scheme have shown that the vast majority of barn owls contain one or more rodenticides. In 2015, for example, 94% of barn owls were found to contain rat poison, and in 2011, 100% of kestrels and 94% of red kites were similarly contaminated. In the vast majority of cases the level of contamination was sub-lethal. In one British study, only 12 out of 1009 barn owls found dead in the wild succumbed as a result of rodenticides. Unfortunately the effects of sub-lethal doses are unknown.

Experimental studies performed in India, England and the USA have clearly shown that barn owls die if they regularly eat mice poisoned with anticoagulant rodenticides. However, if sub-lethal contamination is affecting behaviour, survival or productivity, the full impacts of poison on barn owl populations may be far more substantial than assumed.

Barn owls as biological pest control agents

The use of anticoagulant rodenticides is a major environmental problem. We therefore need to find an environmentally friendly solution that satisfies farmers and the consumers of agricultural products, a growing proportion of whom request organic food. The barn owl feeds almost exclusively on small mammals located in agricultural fields: the species can be locally common, and where prey is abundant each pair can produce many hungry nestlings. Indeed, a family of barn owls can consume more than 6000 voles in a single year!

In several countries, farmers and ornithologists have understood the key role played by barn owls in agriculture. In Israel, Malaysia, the USA and Venezuela large numbers of nest boxes have been erected, to favour this 'biological pest control agent' over the use of chemicals to control small mammals. In Malaysia, damage to rice fields due to rats is significantly lower when the density of nest boxes is higher, which indicates a positive effect of barn owls on agriculture. Economic analyses in Israel further suggest that the addition of barn owl boxes leads to a net economic benefit for farmers (US$235 per hectare per year), who can spread less rodenticide and simultaneously improve crop yield by 9.4%. The gain is even higher when we consider that the reduced use of rodenticides helps preserve soils and can bring public health benefits for human populations. Clearly this is a win–win solution. More data are needed to evaluate the positive impact of barn owls in combating small mammals in other countries.

Do not introduce owls on islands

The success story of the barn owl as a biological pest control agent has inspired ecologists. They have introduced this species on several islands to combat mice and rats that were themselves introduced by humans. South African barn owls

https://doi.org/10.1017/9781316694114.004 Published online by Cambridge University Press

The barn owl hunts rodents very efficiently and is therefore a perfect pest control agent.

were successfully introduced on St Helena in 1937 and the Seychelles in 1951, Californian owls in Hawaii in 1958–1963 and Australian masked owls on Lord Howe Island between 1922 and 1930. However, we should not forget that the barn owl is particularly successful in colonizing new regions and is an efficient predator. Generally speaking, biodiversity on islands is impoverished compared to that on the mainland. In situations where there are few small mammals to consume, barn owls can turn to eating endemic or rare birds, especially where they are vulnerable to predation. If the (re)-introduction of animals is necessary, it should be done using local individuals reared in breeding facilities, if possible. Furthermore, biological pest control is best performed using a predator that is already present on an island rather than a new animal whose presence might have disastrous consequences.

FUTURE RESEARCH

- The abundance of rodents, rodent damage and crop yield should be measured in controlled experimental field trials where barn owls (1) can breed in nest boxes and (2) cannot breed in nest boxes.
- Eco-toxicological studies should be performed not only on dead owls but also on live owls.
- The effect of low levels of contamination should be explored.

https://doi.org/10.1017/9781316694114.004 Published online by Cambridge University Press

Nest box monitoring in Israel. © Laurent Willenegger

FURTHER READING

Albert, C. A., Wilson, L. K., Mineau, P., Trudeau, S. and Elliott, J. E. 2009. Anticoagulant rodenticides in three owl species from western Canada, 1988–2003. *Arch. Environ. Contam. Toxicol.* **58**: 451–459.

Ansara-Ross, T. M., Ross, M. J. and Wepener, V. 2013. The use of feathers in monitoring bioaccumulation of metals and metalloids in the South African endangered African grass-owl (*Tyto capensis*). *Ecotoxicol.* **22**: 1072–1083.

Barn Owl Trust. 2012. *Barn Owl Conservation Handbook*. Exeter: Pelagic, pp. 258–271.

Christensen, T. K., Lassen, P. and Elmeros, M. 2012. High exposure rates of anticoagulant rodenticides in predatory bird species in intensively managed landscapes in Denmark. *Arch. Environ. Contam. Toxicol.* **63**: 437–444.

Denneman, W. D. and Douben, P. E. 1993. Trace metals in primary feathers of the barn owl (*Tyto alba guttata*) in the Netherlands. *Environ. Pollut.* **82**: 301–310.

Elliot, J. E., Hindmarch, S., Albert, C. A., Emery, J., Mineau, P. and Maisonneuve, F. 2014. Exposure pathways of anticoagulant rodenticides to nontarget wildlife. *Environ. Monit. Assess.* **186**: 895–906.

Eulaers, I., Jasper, V. L. B., Pinxten, R., Covaci, A. and Eens, M. 2014. Legacy and current-use brominated flame retardants in the barn owl. *Sci. Total Environ.* **472**: 454–462.

González Amigo, S., Simal Lozano, J. and Lage Yusty, M. A. 2002. Extraction of polycyclic aromatic hydrocarbons in barn owls (*Tyto alba*) from northwest Spain by SFE and HPLC-FL analysis. *Polycyc. Aromat. Compd.* **22**: 1–11.

Hafidzi, M. N. and Na'im, M. 2003. The use of the barn owl, *Tyto alba*, to suppress rat damage in rice fields in Malaysia. *Aciar Monograph* **96**: 274–277.

Labuschagne, L., Swanepoel, L. H., Taylor, P. J., Belmain, S. R. and Keith, M. 2016. Are avian predators effective biological pest control agents for rodent pest management in agricultural systems? *Biol. Control* **101**: 94–102.

https://doi.org/10.1017/9781316694114.004 Published online by Cambridge University Press

Barn owls on islands can specialize in hunting rare birds. This nest on the Alegranza archipelago in the Canary Islands is located in a hole in the ground and is surrounded by feathers of Bulwer's petrels. © Laura Gangoso

Mendenhall, V. M. and Pank, L. F. 1980. Secondary poisoning of owls by anticoagulant rodenticides. *Wilson Soc. Bull.* **8**: 311–315.

Newton, I. and Wyllie, I. 2002. Rodenticides in British barn owls. In Newton, I., Kavanagh, R., Olsen, J. and Taylor, I. (eds) *Ecology and Conservation of Owls*. Melbourne: CSIRO, pp. 286–295.

Newton, I., Wyllie, I. and Freestone, P. 1990. Rodenticides in British barn owls. *Environ. Pollut.* **68**: 101–117.

Newton, I., Wyllie, I., Gray, A. and Eadsforth, C. V. 1994. The toxicity of the rodenticide flocoumafen to barn owls and its elimination via pellets. *Pest. Sci.* **41**: 187–193.

Saravanan, K. and Kanakasabai, B. 2004. Evaluation of secondary poisoning of difethalione, a new second-generation anticoagulant rodenticide to barn owl, *Tyto alba* Hertert under captivity. *Indian J. Exp. Biol.* **42**: 1013–1016.

Shore, R. F., Walker, L. A., Potter E. D., Pereira, M. G., Sleep, D., Thompson, N. J. 2017. Second generation anticoagulant rodenticide residues in barn owls 2016. CEH contract report to the Campaign for Responsible Rodenticide Use (CRRU) UK, 21 pp.

Walker, L. A., Chaplow, J. S., Llewellyn, N. R., Pereira, M. G., Potter, E. D., Sainsbury, A. W., and Shore, R. F. 2013. Anticoagulant rodenticides in predatory birds 2011: a Predatory Bird Monitoring Scheme (PBMS) report. Lancaster: Centre for Ecology & Hydrology.

https://doi.org/10.1017/9781316694114.004 Published online by Cambridge University Press

An image from the past in Europe. A barn owl crucified on a door was believed to ward off evil spirits in Christian countries. Unfortunately, in many parts of the world, barn owls are still believed to be harbingers of bad luck.

2.5 WHAT CAN WE DO TO PROTECT BARN OWLS?

Joining forces to protect nature

We must welcome any effort seeking to preserve the environment and promote sustainability. Measures applied at large geographic scales, such as restoring habitats and adding artificial nest sites, are particularly efficient in protecting barn owls. Preventive and educational action should be taken to reduce owl mortality.

Owl populations are at risk. Major causes of population declines include loss of hunting habitats and nest sites, man-made hazards including traffic, toxic chemicals and increased human disturbance, predation, harsh winters and other extreme weather events. The list of risks is too long, and we need to deploy a number of conservation measures to help owls. Four approaches can be implemented, namely:

(1) Conservation measures targeted at populations
(2) Saving injured or starving individuals
(3) Prevention of harmful activities
(4) Education of the human population

The concept of nature conservation is broad enough to salute any effort made in the right direction to help our environment, restore or protect biodiversity, sustain populations and ensure the wellbeing of each individual. These are the humble streams that flow into great rivers.

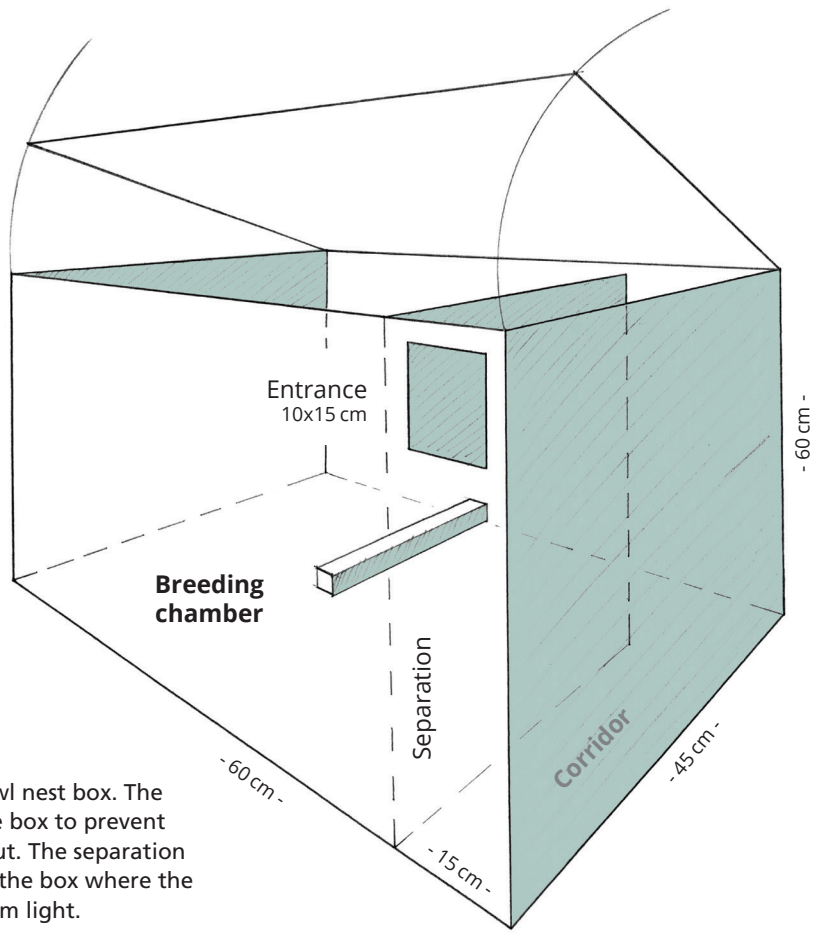
Targeting the population In many regions, populations have declined dramatically. To address the situation, we can treat either the causes of such declines or the symptoms. Although these approaches are sometimes complementary, they do not always have the same value. For example,

https://doi.org/10.1017/9781316694114.004 Published online by Cambridge University Press

a breed-and-release programme will have little impact if it does not ensure that the released birds can breed and survive. In the 1980s, owl enthusiasts in the United Kingdom were releasing at least 3000 captive-bred owls per year. In Iowa, Missouri and Nebraska, 1000 were released annually over a period of six years. Unfortunately, these schemes had no detectable long-term effect on barn owl population levels.

The best measure for preventing and reversing owl population declines is the restoration of their foraging habitat. A return to more traditional forms of agriculture is often advised, because traditional practices benefit not just owls but other organisms as well. However, this may appear utopian, given that some economic models advise the opposite – for example, clearing rainforest for fields of soy or palm plantations. To restore environmental resilience and sustainability, ornithologists, and conservationists, must work at all levels, including in the political sphere, to convince states to implement agricultural methods that are more respectful of nature. We can also work directly with farmers to promote wildlife-friendly measures such as the re-creation of prey-rich foraging habitat and the re-planting of hedgerows that have been sacrificed in the name of agricultural intensification. This will help support not only barn owls, but a wide range of flora and fauna including the owls' prey.

A second measure, and by far the most popular, is the provision of artificial nesting sites. Barn owls adapted to utilizing traditional barns and other man-made structures for nesting thousands of years ago. Since then, many old farm buildings and many of the old hollow trees they used to inhabit have disappeared from the countryside. The conversion of old barns into human dwellings and in some cases an intolerance of sharing space with these creatures has further reduced the availability of suitable sites. A simple solution to this problem is to erect nest boxes in rural buildings, on trees, or on poles.



Schematic view of a barn owl nest box. The entrance is at the top of the box to prevent the nestlings from falling out. The separation ensures that the portion of the box where the owls lay eggs is shielded from light.

https://doi.org/10.1017/9781316694114.004 Published online by Cambridge University Press

In regions where site availability is a limiting factor, the provision of nest boxes over wide areas can help populations expand through immigration from neighbouring 'source' populations. In very hot climates, boxes should be placed in shady areas to prevent eggs and owlets from overheating.

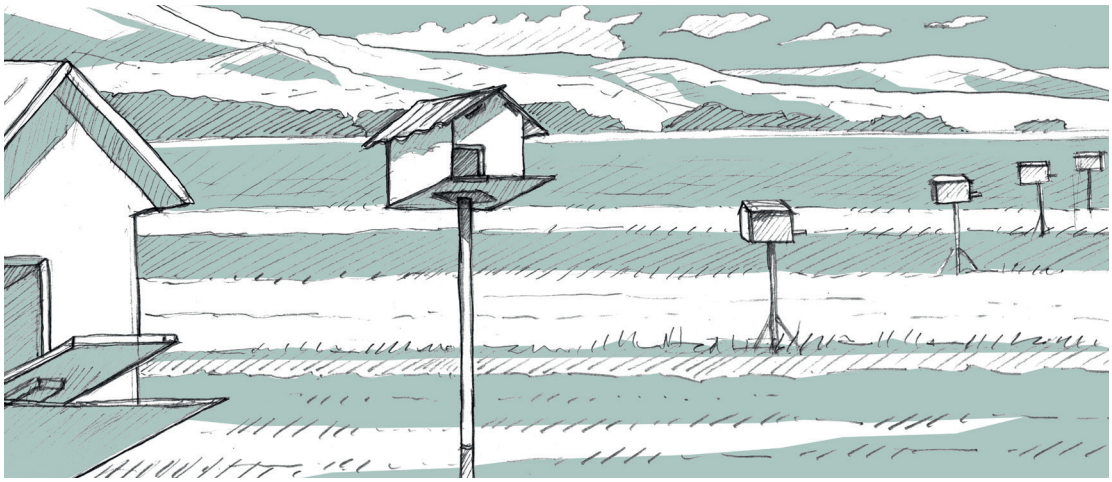
In the United Kingdom, an estimated 25 000 barn owl nest boxes had already been erected by 1997, and since then many thousands more have been provided – but there has been little benefit across most of the country, where food availability is the limiting factor. However, in Denmark, the erection of nest boxes resulted in a 20-fold increase in population size between 1998 (25 pairs) and 2009 (500 pairs). Similar results have been obtained in Germany and the Czech Republic, where there are more than 20 000 and 4 000 nest boxes, respectively.

Saving injured or starving individuals Another approach is to consider individuals rather than populations as the unit of protective intervention. Although such actions are unlikely to have a significant impact on barn owl populations as a whole, these efforts demonstrate that our society respects animals. While ecologists are more concerned with the fate of animal populations or species as a whole, the lay public is particularly sensitive to the vision of suffering and death.

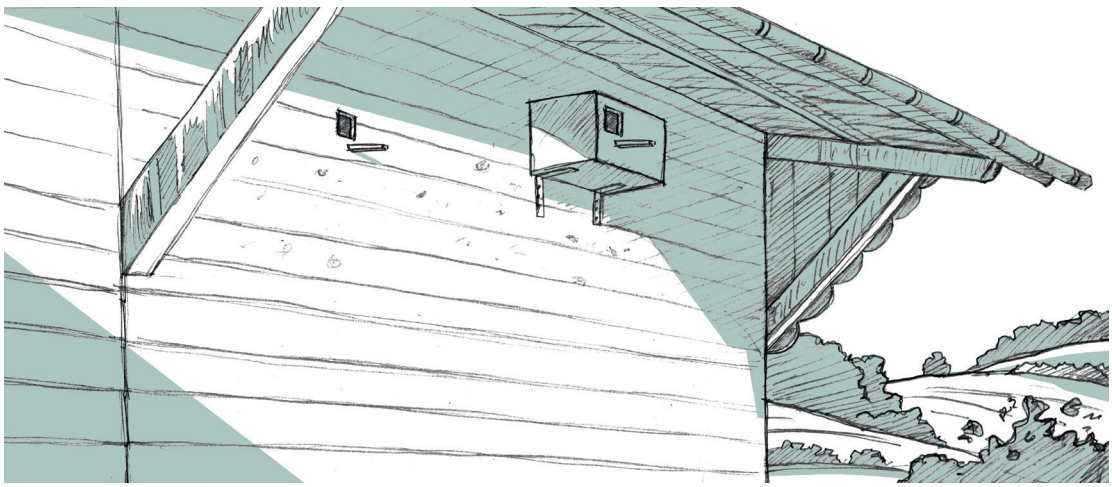
Barn owl nest boxes: a fact sheet

- Nest boxes should be erected to compensate for the loss of historic roosts and nest sites. Because barn owls often change sites to produce a second annual brood, nest boxes are often erected in pairs.
- Boxes should be sufficiently large (e.g. 60 × 60 × 45 centimetres) to host large families and sufficiently deep so the nestlings do not fall to the ground (minimum 45 centimetres from the bottom of the hole to the bottom of the box).
- Boxes are usually made of wood, but in countries where wood is scarce, other material should be used. It is also possible to recycle boxes, such as in Jordan, where ballot boxes are used as barn owl nest boxes!
- Because owls do not bring any material to their nest, a dry organic substance such as wood flakes should be added.
- Pairs of nest boxes are usually placed at least 300 metres apart. However, barn owls are not always territorial and where food is plentiful nests can be very close together.
- Nest boxes can be installed in isolated barns. However, in some countries boxes are usually erected in church towers in villages, to enable the barn owls to evade nest predation by martens. Nest boxes can also be installed in busy or noisy places, as barn owls that are able to hide can learn to tolerate loud noises. Provision for barn owls should be incorporated into rural barn conversions. Provided this is done well, there are no health or nuisance implications.
- Nest boxes are normally installed not less than 3 metres above the ground. However, where martens are likely to be a threat, they should be fixed at a height of at least 5 metres. It may also be necessary to take extra steps to prevent predator access.
- In very hot climates, nest boxes can have a double wall and roof, and additional ventilation, to keep the inside of the box from overheating. In addition, when fixing a box inside a barn, one should avoid fixing it at the highest point where ambient temperature may be higher.
- Owls like to remain in dark places during daylight hours. A separation between the nest entrance and the place where the owls lay the eggs is recommended, to ensure that a large portion of a nest box remains in the dark.
- For further information see the *Barn Owl Conservation Handbook* or visit www.barnowltrust.org.uk.

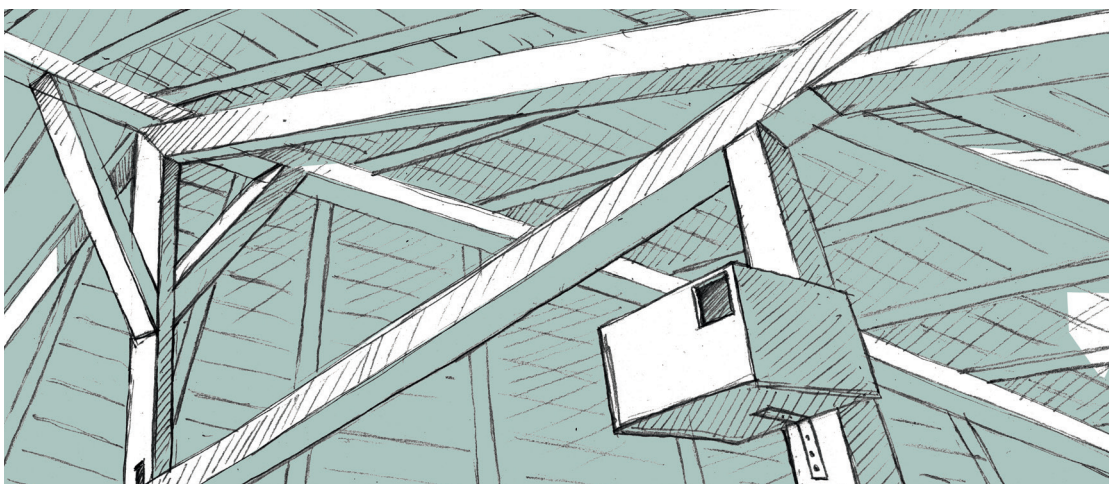
https://doi.org/10.1017/9781316694114.004 Published online by Cambridge University Press



In the Middle East, nest boxes are often fixed on poles in fields.



Nest boxes can be fixed against the walls of barns, with the box being either outside or inside the building. When inside, a hole is pierced in the wall so that the owls enter the box from the outside.



Nest boxes can be fixed inside barns, although in this situation there is a risk that martens will reach barn owl nests.

https://doi.org/10.1017/9781316694114.004 Published online by Cambridge University Press

Barn owls are fascinating and can be a flagship species for nature conservation.

https://doi.org/10.1017/9781316694114.004 Published online by Cambridge University Press

In many countries, nature lovers, and even governments, have created rehabilitation centres to treat injured and food-deprived animals. Large numbers of individuals can be saved in this way, as shown in Germany, where treated barn owls have a high survival rate once released into the wild. Because a major cause of mortality is starvation, rehabilitation centres in Spain have encouraged released barn owls to remain nearby by offering shelter and food. The use of supported or 'soft' release methods substantially enhances their survival. However, individuals that have suffered serious trauma, such as bone fractures, have less chance of survival once released – and for them a supported release method is equally important. Individuals that never fully recover fare much better when kept in captivity rather than left to their fate in the wild. Captive disabled birds can sometimes be used in educational programmes. However, they never become tame and tend to suffer stress. Most owls used for educational purposes are captive-bred and hand-reared.

Straightforward, simple actions can save individual birds. Ornithologists also sometimes have the opportunity to reunite families or create new families. When food supply is momentarily low – owing, for instance, to inclement weather that inhibits foraging – hungry offspring try to attract the attention of their parents by remaining close to the entrance of the nest cavity and calling. When a parent finally arrives with food, nestlings sometimes push each other in an attempt to get the food, and one may accidentally fall out of the nest. Because parents do not feed their offspring outside the nest, the fallen individual will starve unless returned to its siblings. When a nest is destroyed or a nestling is orphaned, ornithologists can transfer young to other nests to be adopted by parents who are apparently unable to distinguish their own offspring from others.

Prevention of harmful activities Most causes of mortality are known, and simple measures can sometimes prevent them. For instance, nestlings can be prevented from falling by the provision of deep nest boxes. Cattle often drink from large water tanks placed in fields. When thirsty owls land on the edge of these tanks to drink or to take a bath, they frequently drown. A simple solution to this problem is to install a wooden float that can support the weight of an owl but still allows the cattle to drink.

Owls are also often trapped inside abandoned buildings: while it may be easy to find an entrance, it is sometimes more difficult to find an exit! Leaving a window wide open would prevent owls from starving to death. Additionally, owls fly close to the ground and thus often collide with cars and trucks. To reduce the risk of collision, roads would be safer if placed lower than the surrounding fields or screened with trees and shrubs to force the owls to fly above the height of most vehicles. Electricity supply cables on poles can be insulated to prevent birds being electrocuted. Unwanted rodent populations can be controlled by environmental management rather than the use of highly toxic poisons. Starvation can be reduced by the provision of prey-rich habitat, and nest mortality can be reduced by providing safe nesting places inside rural buildings.

Fascination Owls have long fascinated humans, for good and bad reasons. There are still countries where people capture owls from their nests and sell them in markets as pets. Owls also stimulate human imagination. Perhaps one of the most famous recent examples is the role played by owls, particularly the snowy owl, in movies such as the Harry Potter series (which also caused an increase in owls being caught for the pet trade). Conservationists should capitalize on this fascination and harness public support for their conservation.

Education The power of education to change perceptions is undeniable. In the past, European farmers nailed (or crucified) barn owls against the walls of their farms to ward off evil spirits. Crucifying owls was so frequent in the United Kingdom that this bird was known as the 'barn door owl'! Nowadays, in stark comparison, awareness is spreading in the farming community and some farmers proudly invite their friends to see how cute barn owl chicks are. Nevertheless, in some countries, barn owls are still

https://doi.org/10.1017/9781316694114.004 Published online by Cambridge University Press

A barn owl parent bringing a wood mouse to its nest in France. © Alex Labhardt

https://doi.org/10.1017/9781316694114.004 Published online by Cambridge University Press

Barn owls often hunt by flying just above the ground, and hence are at risk of collision with cars.

considered bad omens. But it is only a matter of time before people realize that these birds help farmers by eating mice, rats and voles. Education about the importance of owls in maintaining a balanced ecosystem is essential. Unfortunately, other powerful interests are at play – agrochemical industries encourage farmers to use their chemical products and may see a move towards nature-friendly methods as a threat to their profits.

FURTHER READING

Bairlein, F. and Harms, U. 1994. Ortsbewegungen, Sterblichkeit und Todeursachen von Greifvögeln und Eulen nach Ringfunden der 'Vogelwarte Helgoland' – eine übersicht. *Vogelwarte* **37**: 237–246.

Barn Owl Trust. 2012. *Barn Owl Conservation Handbook*. Exeter: Pelagic.

Colvin, B. A. 1981. Nest transfer of young barn owls. *Ohio J. Sci.* **81**: 132–134.

Fajardo, I., Babiloni, G. and Miranda, Y. 2000. Rehabilitated and wild barn owls (*Tyto alba*): dispersal, life expectancy and mortality in Spain. *Biol. Conserv.* **94**: 287–295.

Graves, G. R. 2016. Observation of a barn owl (*Tyto alba*) bathing in a rainwater pool in Jamaica. *J. Caribb. Ornithol.* **29**: 16–17.

Nijman, V. and Nekaris, K. A.-I. 2017. The Harry Potter effect: the rise in trade of owls as pets in Java and Bali, Indonesia. *Global Ecol. Conserv*. **11**: 84–94.

https://doi.org/10.1017/9781316694114.004 Published online by Cambridge University Press