UK Civil Aviation Authority

The Effects of Aircraft Noise on Biodiversity

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Contents

CHAPTER 1
Introduction

1.1 This report was commissioned by the Department for Transport and is intended to be a concise overview of the current knowledge on the impacts of aircraft noise on biodiversity. The definition of biodiversity is: “the variety of plant and animal life in the world or in a particular habitat, a high level of which is usually considered to be important and desirable”. It includes all terrestrial (land-dwelling), marine (aquatic) and other different ecosystems and ecological complexes. Biodiversity is essential for all processes in nature and supports all life, including humans.

1.2 The International Civil Organisation (ICAO) published their Environmental Report (2022) which presents the progress made over the previous three years across key areas of ICAO’s environmental protection activities. It states that:

‘Like many different sectors impacting biodiversity, the aviation sector can have adverse effects on biodiversity in a number of ways, including habitat loss when airports and airfields grow, the dispersal or management of wildlife for practical purposes, and the effects of light and noise pollution on particular species. The impacts of aviation on biodiversity many times are addressed in the context of airport planning and thus it is important that the environmental assessments put more effort in identifying sensitive habitats, relevant risks and appropriate climate change mitigation (i.e. aircraft technologies, operational improvements, relocation/re-creation of habitats elsewhere to provide home for flora and fauna upon expansion, etc.)’

1.3 ICAO state that with regard to pollution from aviation; fish, mammals, reptiles, amphibians, and invertebrates can all be extremely susceptible to light and noise pollution.

1.4 This CAP report contains summaries of the available findings in this research area, and also includes references to findings from other transportation noise sources that are considered relevant to further understanding of man-made noise impacts on biodiversity.

CHAPTER 2

Findings on Aircraft Noise and Biodiversity

2.1 Bristol University published a report for Defra on the effects of noise on Biodiversity in 2012. Defra commissioned this review to collate the literature on the impacts of anthropogenic (man-made) noise on non-marine UK species, with a particular focus on UK Priority Species (UK PS) and Species of Principal Importance (SPI) for England, Northern Ireland, Scotland and Wales.

2.2 86 publications were found directly addressing the impact of anthropogenic noise on non-marine species were identified, of which 16 focused on UK PS and SPI. Overall patterns were generally similar whether considering studies on species throughout the world, on all UK species or on UK PS and SPI only. The report stated that the literature is dominated by studies on road traffic noise (60% of studies with 15% of studies on aircraft noise), on birds, and on behavioural impacts.

2.3 The report's overall conclusions were that the major finding was that a strong evidence base does not exist regarding the potential impact of anthropogenic noise on non-marine UK PS and SPI. Definite conclusions could be made only about the reed bunting (Emberiza schoeniclus), which exhibits shifts in song frequency in response to road traffic noise. It is also likely that foraging in brown long-eared bats (Plecotus auritus), singing in European robins (Erithacus rubecula), house sparrows (Passer domesticus), starlings (Sturnus vulgaris) and bullfinches (Pyrrhula pyrrhula), and the behaviour of common toads (Bufo bufo) are affected by road traffic noise to some degree. Common issues preventing strong conclusions for other species include a lack of sufficient controls to rule out potential confounding factors (e.g. changes in the behaviour of animals near roads may be the consequence of differences in lighting, disturbance or habitat differences, rather than noise) and the use of acoustic measurements that are more relevant to humans than the auditory capabilities of the study species.

2.4 The report explains that there are few anthropogenic noise studies, both globally and in the UK, that allow strong conclusions about the impact of anthropogenic noise on non-marine animals. Studies from around the world and the UK as a whole share similar proportions of publications in each evidence category. Studies on UK PS and SPI, however, provide an overwhelming lack of strong evidence for or against noise impacts.

2.5 Some key issues that prevent strong conclusions recur often throughout the literature on anthropogenic noise impacts. The most common of these is a failure to provide suitable controls for confounding factors. Confounding factors are variables that could contribute towards variation in the study subjects. For example, roads are noisy, but they also have high levels of disturbance, pollution and light. Studies

often compare the responses of animals near a noisy road with those in a control area, either a quieter road or a site at a greater distance from the road, but such a situation does not allow any differences to be conclusively attributed to noise. Aside from the importance of suitable controls, it is also vital to quantify the noise source in the most appropriate way for the study species.

2.6 Most research has been conducted on birds regarding noise effects. Most direct anthropogenic noise studies on birds have addressed the impact of road traffic noise, with song frequency shifts under noisy conditions a common finding.

2.7 The impact of aircraft noise has also been studied in several birds on the UK PS and SPI lists. The report concludes that with aircraft noise studies it is difficult to eliminate confounding factors without experimental manipulation of the noise source. These studies, being field-based and generally observational, therefore do not provide great weight when drawing conclusions about the impact of aircraft noise on UK wildlife.In 2003 **Pepper et al** from Texas Tech University published a report on the effects of aircraft noise on wildlife and humans, and the need for further study. The paper summarised previous studies on aircraft noise and wildlife, including military aircraft noise affecting flushing responses in bald eagles, and the fright response in animals to noise, causing responses such as running or flying away from the noise. One study suggested that aircraft above 500m did not provoke a noise-induced response in birds of prey.

2.8 Studies on deer and sheep have suggested that aircraft noise may be linked to increased heart rate. In general, there does not appear to be any long-term effects of aircraft noise on productivity or reproduction in studies on mink and cattle, although the studies mentioned are very old and there are a lot more aircraft movements now. The paper suggests further research into the impact of aircraft noise on wildlife is needed; specifically, multidisciplinary research with the aim of determining to what degree these impacts are, and what realistic solutions may exist.

2.9 **Wolfenden et al** published a study into aircraft noise exposure and song frequency decline and elevated aggression in wild chiffchaffs in 2019. The study looked at common chiffchaffs living close to planes taking off and landing and found that they were five times more likely to attack a speaker emitting bird song than their counterparts who lived away from airport noise.

2.10 The research was by Manchester Metropolitan University in partnership with Manchester airport, and also found birds living close to airports are exposed to extreme noise levels from jet engines that interfere with their communication with mates and rivals, since males defend their territories by singing from strategic positions throughout the breeding season.

2.11 Researchers from Manchester Metropolitan University, Leiden University, and the University of Manchester recorded the songs of birds close to Manchester airport

and Amsterdam's Schiphol airport at a distance of between 180m and 2,100m from the runways, and from birds living 20km away.

2.12 Using a remote-controlled playback speaker, pre-recorded male songs were played, mimicking a nearby rival. Populations close to the airport were more aggressive, attacking the speaker 5 times more than control birds.

2.13 In contrast to the general pattern of increased song frequency in noisy areas, the researchers found that common chiffchaffs at airports show a negative relationship between noise exposure level and song frequency.

2.14 The study also indicated that the airport birds changed their style of song, using lower maximum and peak frequencies and delivering syllables at a slower rate. This suggested possible noise-induced hearing loss, a potential reason behind the birds' aggression. Laboratory studies of hearing-impaired birds have shown a similar change, but this is the first time it has been observed in wild birds.

2.15 The paper explains that since the decrease in song frequency results in increased overlap with aircraft noise, these findings cannot be explained as an adaptation to improve communication. The increased levels of aggression suggest that chiffchaffs, like humans, might be affected behaviourally by extreme noise pollution. It is stressed that these findings should influence environmental impact assessments for airport expansions throughout the world.

2.16 **Alquezar and Macedo** authored a paper on airport noise and conservation with the question posed: what are we missing? The paper examines the existence of Natural Protected Areas (PAs) of high priority conservation located within noise-impacted areas of Brazilian airports and discusses how noise can generate physiological stress and jeopardise wildlife breeding.

2.17 The authors highlight the main effects of noise on wildlife many behavioural changes, such as increased alert behaviour, modifications in vocal behaviour, and lower reproductive success. Airport laws concerning wildlife in Brazil only address the risk of wildlife–aircraft collision and do not consider the impact of airport noise on wildlife welfare in Protected Areas.

2.18 Noise primarily causes sound masking, jeopardising animal communication and eliciting costly changes in sound production, affecting birds, cetaceans, insects, frogs, and other taxonomic groups. Because birds depend upon communication for reproductive purposes, exposure to continuous noise has been reported to cause decreases in nest success, brood size, nestling growth rates, and egg success. This reduced reproductive success brings in turn reductions in population sizes and decreased species richness and diversity in areas impacted by noise, which even results in changes in patterns of seed dispersion and pollination. Another consequence of noise masking is the change in alertness, increasing vigilance behaviour in detriment of other daily activities. This constant state of alertness associated with stress can bring negative physiological consequences.

2.19 The authors explain that noise-elicited stress is the key factor that strengthens the argument that wildlife exposure to chronic noise can jeopardise medium and large sized mammal reproduction in conservation areas affected by noise. Sporadic stressful situations (e.g., noise, predation attempts, food shortage) can cause the release of glucocorticoids, which help individuals to deal with novel situations, and even enhance the immune system. However, exposure to constant stressful situations can generate a range of physiological responses, including a decline in immune condition. In vertebrates, glucocorticoid production and release occur in the hypothalamic–pituitary–adrenal (HPA) axis, and reproduction control occurs in the hypothalamic–pituitary–gonadal (HPG) axis. High levels of glucocorticoid are associated with a suppressed secretion of gonadotrophin releasing hormone (GnRH), luteinizing hormone (LH), and follicle stimulating hormone (FSH), all of them critical for mammalian reproduction.

2.20 Sexually mature adults, pregnant females and offspring that are chronically exposed to stressful events can suffer severe consequences. Few studies have evaluated the effect of noise stress on mammalian reproduction. There are, however, studies that explore how other types of stress affect mammalian reproduction.

2.21 Stress-related effects prior to copulation include reduced fertility, reduction of gonad size (hypogonadism), decreased production of sperm which may be of lower quality, and in females, compromised maturation and reduced fertility of oocytes. If copulation, fertilisation, and embryo implantation occur successfully, pregnant females exposed to high glucocorticoid levels can experience gestational stress, which will negatively affect offspring development. Gestational stress can jeopardise the development of foetal brain structures and function, affecting future offspring behaviour and ability to deal with novel situations. Studies investigating pre-natal stress resulting from noise have shown that offspring may develop less reactive immune systems.

2.22 The authors examine what is in place elsewhere in the world for the protection of wildlife from aircraft noise. In Europe, this area also seems to be lacking, and heavily focussed on human perception without suitable consideration of wildlife protection. They conclude by stating that their intention was to provide scientific information to support policymakers, emphasising the need for regulatory laws that define the acceptable levels of noise incidence over Brazilian Natural Protected Areas. They stress that the mitigation of airport noise over Protected Areas is of utmost importance for wildlife conservation.

2.23 **Sordello et al** published a paper that describes the methodology currently in progress to develop a systematic map protocol for the evidence of environmental noise on biodiversity. The resulting map will inform on the species most studied and on the demonstrated impacts. This will be useful for further primary research by identifying knowledge gaps and in view of further analysis, such as systematic reviews. Exposures will include all types of man-made sounds (industrial, traffic,

etc.) in all types of environments (terrestrial, aerial, aquatic), including all contexts and sound origins (spontaneous or recorded sounds, in situ or laboratory studies, etc.). All relevant outcomes will be considered (space use, reproduction, communication, abundance, etc.). The aim is to produce an open-access database with all relevant studies included that were selected during the screening stages. This database will be available in conjunction with a map report describing the mapping process and the evidence base with summary figures and tables of the study characteristics. Based on these results, recommendations will be made on priorities for future research and mitigation of noise pollution.

2.24 **Kunc and Schmidt** authored a meta-analysis on the effects of anthropogenic noise on animals. They conducted a meta-analysis on the effects of noise on more than 100 species, including amphibians, arthropods, birds, fish, mammals, molluscs and reptilians. 108 experimental studies were included on 109 species. The noise sources **did not** include aircraft noise, but did include traffic noise and other man-made noises such as air guns, artificial low-frequency noise and boat noise, amongst others. Figure 1 shows the effects of anthropogenic noise on taxonomic groups. Shown are the standardised mean differences (SMDH) and 95% confidence intervals (CIs) from random-effects models. The dashed line at zero indicates no effect of anthropogenic noise; an effect of noise occurs if the 95% CI of the SMDH does not overlap zero.The authors found that the included anthropogenic noise causes significant responses, but taxonomic groups did not differ in their response to noise. When analysing each taxonomic group separately, each group showed a significant response to noise. In both the overall model and in the separate models for each taxonomic group, heterogeneities (variation in study outcomes between studies) stemmed mostly from inconsistencies among effect sizes and studies.

2.25 The authors conclude that this study provides the first comprehensive quantitative empirical evidence that noise affects many aquatic and terrestrial species. They explain that the results are particularly important from a conservation point, because they show that noise affects not only a few species, but many species that inhabit very different ecosystems, and that anthropogenic noise must be considered as a serious form of environmental change and pollution.

2.26 **Sierro et al** from Madrid published a paper on the effects of aircraft noise on blackbirds' chorus and song behaviour. The blackbird population around Madrid airport was studied and compared to a control group in a silent area of forest. Figure 1 shows a comparison between the airport site and forest in terms of noise levels during early morning.

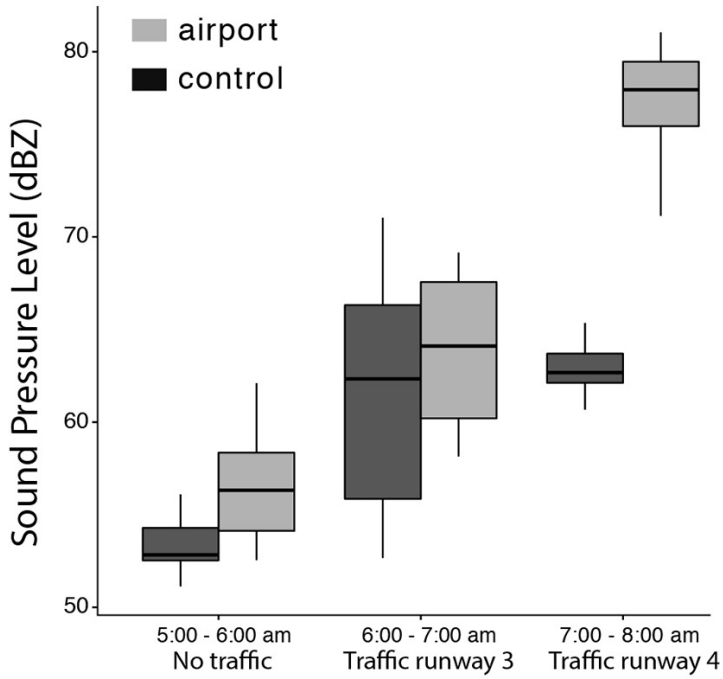

Figure 1: Noise levels at both sites during early morning.

2.27 Before 6 a.m there are some small differences between sites that disappear at 6 am. However, obvious differences between study sites arise at 7 am with the onset of the daytime traffic schedule.

2.28 Blackbird song is composed of two parts: a series of loud low-frequency whistles (motif) and a final flourish (twitter). The study found that blackbirds around the airport were more likely to sing songs without the twitter part. Also, when songs included a twitter part, airport blackbirds used a smaller proportion of song for the twitter than control blackbirds. The results showed no differences in song frequency between airport and control populations. However, airport blackbirds not only sang earlier but also increased the time they spent singing when chorus and aircraft traffic overlapped on time. This effect disappeared as the season progressed and the chorus and the aircraft traffic schedule were separated in time.

2.29 The authors suggest that the modifications in singing behaviour induced by aircraft noise may be adaptive and that they are specific to airport acoustic habitat and found that adjustment of singing activity in relation to noise is plastic and possibly optimised to cope with aircraft traffic activity, though this suggests higher fitness costs in relation to daily energy expenditure.

2.30 **Vincelette et al** published a paper in 2020 on the effect of aircraft traffic on avian vocal activity. This study aimed to understand the effect of aircraft traffic and associated noise on the richness (species counted per minute) of bird vocalisation activity in a remote national park in the USA. Two sites at Denali National Park in Alaska were selected, both of which experience little human presence or activity, and the authors quantified the richness of bird vocalisations before, during and after aircraft events.

2.31 The results support evidence of an avian community-level behavioural response to aircraft noise, with increased bird vocalisation richness after aircraft events at a site with relatively lower aircraft noise. At the site with low rates of aircraft noise, bird vocalisation richness did not significantly change during an aircraft event but did increase after an aircraft event. At the site with higher rates of aircraft noise, bird vocalisation richness did not significantly change during or after an aircraft event.

2.32 The authors explain that the apparent lack of response to aircraft noise at the site with higher aircraft audibility potentially indicates the bird community has become habituated to noise, or comprises noise-tolerant species, and/or site-specific features alter aircraft noise propagation and perception. The results provide evidence of a bird community changing vocal behaviour in response to aircraft noise in a remote park and highlight the complex nature of community response to anthropogenic noise.

2.33 The authors suggest that this study provides new insights into wildlife responses to aircraft traffic and associated noise and highlights the importance of noise research in the management of relatively quiet and undisturbed landscapes, and the need to explore aircraft noise as a potential driver of biodiversity loss.

2.34 **Alquezar et al** examined the responses to aircraft noise in dawn song timing of bird populations near tropical airports. The aim was to investigate whether 15 tropical bird species were able to advance their dawn song and avoid aircraft noise interference. Dawn song was monitored at three airports and three control sites in Brazil, using automated recording units.

2.35 The findings suggested that dawn song times were not globally affected by the exposure to airport noise. Instead, changes were highly variable and species-specific, as dawn song onset was significantly advanced in two and delayed in four species. This is the first time that a significant delay has been reported for bird's dawn song. The authors suggest that earlier airport activity and shorter variations in day length and in twilight duration of tropical areas may be restricting birds' ability to change dawn song timing. They recommend that further studies should consider these differences and analyse to what extent populational declines in noisy areas and the resultant reduced competition for acoustic space may be affecting the changes in dawn chorus onset time.

2.36 **De Framond and Brumm** examined the long-term effects of noise pollution on the avian dawn chorus. This study utilised findings from a pervious study that examined birdsong following the closure of Berlin Tegel airport. The authors describe the findings that indicate that proximity airports, where noise levels are particularly high, birds start singing earlier in the morning, probably to gain more time of uninterrupted singing before air traffic sets in.In 2020 Tegel airport closed down and the authors were able to assess the long-term impacts of noise on birdsong, and to study the potential mechanisms by which such changes may occur.

2.37 The findings suggested that several species at the airport shifted their song onset back after the closure and now had similar schedules to other birds of the same species observed at a control site. Some species, however, still sang earlier near the closed airport. The authors propose that while the first suggests plastic adaptation, the latter suggests selection for early singing males in areas with long-lasting noise pollution. It is also stressed that there is a need for more long-term studies on the impact of noise pollution on changes in animal behaviour, and that these changes may persist even when the source of the noie pollution has been removed.

CHAPTER 3

Summary

3.1 This report has provided a high-level summary of the available findings on the impacts of aircraft noise on biodiversity. As set out in the ICAO Environment Report, to cover all aspects of biological diversity across different sectors, including the aviation sector, the Convention of Biological Diversity (CBD) is a global agreement to conserve biodiversity with an overall objective of encouraging actions which will lead to a sustainable future. The convention has three main goals:

- the conservation of biological diversity,
- the sustainable use of its components and the fair and
- equitable sharing of benefits arising from the use of genetic resources.

3.2 Given the vital importance of preserving biodiversity for the future, appetite for further work into the area of human impacts on biodiversity and animal behaviour is increasing. Such research will be important for a greater understanding of the impacts on biodiversity, particularly with respect to aviation noise.

CHAPTER 4

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