



PARAMOUNT ECOLOGICAL RESOURCES

A Publication of PER

<https://paramountecologicalresources.com/>

Review

THREATS TO BIRDS CAUSED BY LAND TRANSPORT IN RURAL AND TOWN LANDSCAPE

Egwumah F.A.^{1*}, Uyeme, J.E.², and Japheth H.D.¹

¹. Department of Forestry and Wildlife Technology, Federal University of Technology Owerri, Nigeria

². Faculty of Biology, University of Adama Mickiewicza in Poznań, Poland

* Correspondence e-mail: egwumahattah@gmail.com, Tel: +2347064621278

Received 12th October, 2021

Accepted for publication 5th January, 2022

Published 5th March, 2022

Recommended citation: Egwumah F.A., Uyeme, J.E. and Japheth H.D. (2022). Threats to Birds caused by Land Transport in Rural and Town Landscape, *Paramount Ecological Resources*, 5 (1):1-7.

Abstract

Continuous expansion of ecological path of human beings is upsetting comprehensive population of wild birds through extensive variety of systems. Land transport can be grouped into two namely; road transport and rail transport. Threats to birds caused by land transport in rural and town differs in so many ways. This paper presents a comprehensive summary using theoretical and empirical information available from literature to discuss the threats to birds caused by land transport in rural and town landscape and how it can be minimized. The threats to birds caused by land transport in rural and town landscape are; direct loss of habitat, noise disturbance, optical disturbance, mortality from collision, behavioral changes, habitat degradation in terms of value, breaking up of habitat (habitat fragmentation), avoidance of road by wildlife species, rapid increase in indiscriminate utilization of wildlife resources by man, interruption of collective organization, reduction in accessibility to important components of wildlife home range, breakup in inhabitant's populations and segregation coupled with interruption in regional populations maintenance proceedings. The following measures could be adopted to reduce the threats caused by land transport in rural and town landscape are: vulnerability of birds to disturbance differs with season for instance rainy season falls into the breeding period of some bird species which coincided with the period when birds' pledges and defend their home range to stimulate fledging and dispersal of young ones. In migratory birds, the period of movement is also important because stopover habitat serves as sources of food for migrating species. Construction of new roads and railways, and maintenance of already existing once should not be schedule during this period because it may reduce visibility and increase threats (such as noise and dust) that are capable of affecting birds. Apart from that, continuous disturbance affects ground nesting resulting to nest abandonment coupled with eggs, young and high threat of being squeeze by vehicles.

Keywords: bird species; roads and rail network; habitat fragmentation; habitat loss; rural and urban landscape; mortality by collisions

INTRODUCTION

Continuous expansion of ecological path of human beings is upsetting comprehensive population of wild birds through extensive variety of systems, of which we are gradually beginning to understand several mechanisms behind it because extinction and population decrease are global problems (Monroe *et al.*, 2019), although not equally stretch across taxa. Variations in ability of bird species to endure

anthropogenic interruption are primary to the generalization of species grouping in surroundings alter my man has been a subject of discuss in the public domain (McKinney and Lockwood, 1999). However, loss of home range, conflict between human and wildlife, indiscriminate harvesting and climate change are renowned anthropogenic factors stimulating extinction of avian species (Cooke *et al.*, 2020) with little knowledge on threats caused by land transport on avian species.

Land transport can be defined as a mode of conveying people, animals or goods from one place to another using land. Land transport can be grouped into two namely; road transport and rail transport. However, both are considered to be long coupled with their linear characteristics on the landscape. Apart from that, it is capable of causing significant threats to bird species and their habitat due to their superior size and elevated traffic volumes. Highways symbolize an added severe threat to bird species.

Land transport is a new ecological area under discussion in recent time with interest from ecologist due to continuous extension and expansion of roads utilized by vehicles. The terrestrial part of the Earth surface holds an estimated concreted road of forty-five million lane-kms designed to service close to 1.3 billion vehicles and this number is expected rise in 2050 to about 70 million lane-km which will serve the expected rise in vehicles of approximately 2.8 billion (Cooke *et al.*, 2020). In most countries there is little or no evidence to minimize the impact of land transport on birds, yet the 6th National Convention on Biological Diversity has come and gone, and the report has been submitted, but only 10% of the countries highlighted roads as a threat to biodiversity (Cooke *et al.*, 2020).

Threats to birds caused by land transport in rural and town differs in so many ways. This paper aims to present a comprehensive summary using theoretical and empirical information available from literature to discuss the threats to birds, caused by land transport in rural and town landscape and how it can be minimized. The threats to birds caused by land transport in rural and town landscape are; direct loss of habitat, noise disturbance, optical disturbance, mortality from collision, behavioural changes, habitat degradation in terms of value, breaking up of habitat (habitat fragmentation), avoidance of road by wildlife species, rapid increase in indiscriminate utilization of wildlife resources by man, interruption of collective organization, reduction in accessibility to important components of wildlife home range, breakup in inhabitant's populations and segregation coupled with interruption in regional populations maintenance proceedings.

Direct loss of habitat

Building of transport infrastructures such as roads and railways in both town and rural areas stimulates modification of the quality of habitat for avian species, but the level of threat posed on birds differs greatly. The environmental threats of roads and their building proceedings on populations of wild birds and its associated resources with respect to biological diversity is quite alarming in recent time because road advancement, shape and alter the habitat form

in a number of ways; for example building of fresh roads converts habitats into extremely distressed surroundings (Rytwinski and Fahrig, 2013; Astudillo *et al.*, 2014; Yrjöla and Santaharju, 2015) thereby reducing the habitat utilized by avian species. Further investigation, also reveals that bird species that are small in size and resident in broad-spectrum are associated with smaller relative abundance once proximity to roads and railways are put into consideration. For instance, green woodpeckers and yellow wagtails. However, wood pigeons, blackbirds and other well established bird species display the reverse (Cooke, 2020).

However, in railways, there is high level of animals with no backbone (earth worm, insects, termites, millipedes and centipedes) and plants diversity along edges of rail track (Moroñ *et al.* 2014), which is an indicator of abundant feeding items attracting birds to such location for foraging. In addition, nearness to railways also reduces observant behaviour exhibited by bird species for example in snowfinches (Ge *et al.*, 2011). It was equally reported by Li *et al.* (2010) that the presence of railway also stimulated an increase in population of seven ground-dwelling bird species. According to Kajzer-Bonk *et al.* (2019) railway embankments possibly will be favourable for bird diversity because it does not modify the functional characteristics of avian communities similar to that of open fields. Appropriate supervision of these straight-line home range will enable us to see the impact of the said home range on bird species in addition to continuous community perseverance.

Noise Disturbance

Ranges of species character have the prospect to influence or forecast links between birds and roads. Noise from frequent utilization of road by vehicles may have more effect on smaller-bodied species vocalization ((Ryan and Brenowitz, 1985; Ryan and Brenowitz, 2003; Parris and Schneider, 2009) as a result of their naturally more quiet and higher-frequency songs, thereby resulting to possibility of bird strike (Santos *et al.*, 2016). Bird species with small body size and others that are migrant are frequently seen in proximity to roads with lesser relative abundance.

This is due to variation in collision rates, frequency of song or inability to cope with noisy environment. A very good example of bird species with lesser relative abundance around constructed roads is chiffchaffs (Cooke, 2020). Apart from that, Rao and Koli (2017), also reported variation in population distribution which is a function of steady noise generated from vehicular traffic.

The degree of the shock of noise pollution on avian species is a function of the age, sexual category, species background, habitat category, season and time of the activity (Summers *et al.*, 2011). In adults' continuous exposure may have effects

on corticosterone concentration in bird species and their nestling. Similarly, this is dependent on the body condition of the nestling (Injaian *et al.*, 2018). With respect to nearness to source of noise pollution, some birds have systems design to adjust their consequence and the level of the effectiveness of these systems, differs with respect to physiological variations among dissimilar species (Curry *et al.*, 2018b). The product of prolong studying of birds specify that habitat alterations and disturbance initiated by road structure and noise from vehicular traffic has huge consequences on reproductive populations of waders, whereas passerine populations demonstrated negligible reaction. A decrease in breeding population of waders was reported by Heikki, (2001) as a result of presence of highway, reducing the conservation value of landscape. The system of traffic interruption may have more impact on specialization of the avian species and it has been documented that wetland habitat birds are most susceptible to disturbance. For instance, European bitterns utilized reed beds usually located faraway from road line. From all indication, habitat modification might not have any significant effect on their disappearance but by car traffic might (Heikki, 2001). However, avian assessment by researchers shows that roads that are characterized by intense traffic has resulted to nesting birds living close to heavy road traffic having a decline in density and species richness (Palomino and Carrascal, 2007; Polak *et al.*, 2013). But from study on avian species over the years, a number of species are gradually becoming more tolerate to disturbance of roads more than others because urban road result to generalization in life of bird species, by now rare species are been dominated by new common ones (Cooke, 2020). Polak *et al.* (2013), reported that birds with low frequency calls and nesting in proximity to the ground are more susceptible to traffic noise that is why birds shy away from high traffic roads because territorial song can only attract mates if and only if the purpose of communicating with other birds for mating is achieved. Distortion in bird songs may result from noise produce by moving vehicles which is capable of making territorial song hard to attract and sustain females for mating (Jacobson, 2005). Distress calls and calls to alert other birds of the presence of predators could be difficult to hear, making avian species to be highly susceptible to predation. Rail network is known for noise pollution which may affect bird species that are singing and the effects is lesser compares to road network (Glista *et al.*, 2009; Kajzer-Bonk *et al.*, 2019). Population perseverance is a function of traffic volume which is the main driving force (Jaeger *et al.*, 2005), and songbirds are capable of keeping away from trains more successfully compares to cars (Heske, 2015).

Optical Disturbance

Similarly, optical disturbances and infiltration of light rays from vehicles into the forest habitat (Pocock and Lawrence, 2005), could also stimulate bird strike. Migration by bird species is only possible through direction-finding by locating the position of stars. Light pollution from other sources cut down the rate the star becomes visible, thereby catching migrating birds in risky surroundings most importantly during bad weather, causing collision, apparent confusion, and mortality (Jacobson, 2005). The outcome of light pollution on flying and migrating birds living in proximity to the bank of rail network might be to a great extent lesser compares to birds living in proximity to road network (Glista *et al.*, 2009; Kajzer-Bonk *et al.*, 2019). Therefore, light pollution outcome seems to be more detrimental to birds living in proximity to roads.

Mortality by Collisions

Bird species with small body size and others that are migrant are frequently seen in proximity to roads with lesser relative abundance. This is due to variation in collision rates, frequency of song or inability to cope with noisy environment. A very good example of bird species with lesser relative abundance around constructed roads is chiffchaffs (Cooke, 2020). (Cooke, 2020). Direct mortality is always the end product once there is a collision with bird species and it is highly pronounced in more than one taxa (Forman *et al.*, 2003). There is low estimation of mortality of avian species caused by highways because most studies concentrated more on mortality from constructions design by human (Jacobson, 2005). According to Jacobson (2005), collision from vehicles has more impact on some birds more than others for example: mortality is higher for walking birds (non-flying), wind storm can pull flying water birds over bridges into moving vehicles, light pollution may cause owls to collide with moving vehicles, using mower for vegetation clearing along highways might kill ground nesters, during foraging, scavengers corvids or raptors are killed on the highways when trying to pick up carcass (Mumme *et al.*, 2000; Jacobson, 2005) and exhausted migrants may crash into moving vehicles during gulf crossing.

Behavioural Changes

An estimated average volume of traffic produced in Poland is 500 automobiles in one hour for local roads whereas close to 3 to 5 trains per hour used the rail network (Kajzer-Bonk *et al.*, 2019) and avoidance of constructed structure by avian species has been reported by Bowgen and Cook, (2018). Population perseverance is a function of traffic volume which is the main driver (Jaeger *et al.*, 2005), and songbirds are capable of keeping away from trains more successfully

compares to cars (Heske, 2015), but innocent birds, possibly will be attracted to roadsides because they serve as a good source of food exposing them to mortality linked to vehicles (Erritzoe *et al.*, 2003; Hell *et al.*, 2005).

Habitat Degradation in terms of Value

Anthropogenic activities have tremendous impact on bird species and their distribution can be used to measure the habitat quality as bio-indicators using of habitat selection model, but various environmental factors may prompt birds to utilize habitat with lesser quality compared to richer ones (Jackson, 2007). Habitat degradation in terms of value may occur if there are changes in hydrology of a stream, emission of greenhouse gases, introduction of exotic floras and release of storm water resulting to degraded home range covering kilometers from rail network and concreted roads (Jackson, 2000).

Breaking up of Habitat

Construction of roads, railways and highways are associated with breaking up of wildlife home range. The aforementioned factors break habitat into small pockets or patches resulting to fragmentation effects and alteration in indigenous home range, habitat modification coupled with additional anthropogenic activities generated by man (Laurance *et al.*, 2004; Laurance *et al.*, 2019). It also divides nonstop home range into home range patches, reduced patch and advanced edge which may extend to interior ratios. A very good example of habitat that is highly beneficial to birds that are notorious for brood parasitism and nest predators is the forest edges linking roads and highways. These birds are serious threats to different species of Neotropical songbirds that are living in the forest edges (Jackson, 2000). Edge-sensitive species are the most affected with the nonstop disappearance of interior habitat. Lesser inclusive patch size may result to a decline in population of area-sensitive wildlife species.

Avoidance of Road by Wildlife Species

The presence of roads and human actions such as anthropogenic activities are considered to be great threats to birds. However, some bird species can avoid such areas head-to-head to highways probably due to noise and other human actions linked to roads (Jackson, 2000). Population perseverance is a function of traffic volume which is the main driver (Jaeger *et al.*, 2005), and songbirds are capable of keeping away from trains more successfully compared to cars (Heske, 2015), but innocent birds, possibly will be attracted to road-sides because they serve as a good source of food exposing them to mortality linked to vehicles (Erritzoe *et al.*, 2003; Hell *et al.*, 2005).

Rapid increase in indiscriminate utilization of Wildlife Resources by Man

Birds are usually exposed to poachers due to presence of roads and highways (Jackson, 2000), thereby reducing the population of avian species especially areas adjoining to roads and highways and keeping them away from trains and cars stimulates road avoidance (Heske, 2015), therefore, mortality of bird species is a product of increased traffic volume, resulting to population loss especially endangered bird species.

Interruption of Collective Organization

Social organization is very important for courtship in wild birds, but road and rail presence reduces the social interaction and survival rate (Jackson, 2000). During spring in temperate zones, majority of the male songbirds demonstrate a plain crest of singing because it falls into the breeding time of year, when they turn out to defend their home range which equally coincides with the period of fertility in females. Within the breeding time of year, the song output produced by males differs considerably with respect to their reproductive conditions of their mate but the presence of increased traffic volume from rail and car might interfere with courtship calls (Naguib and Riebel, 2014).

Reduction in Accessibility to important Components of Wildlife Home Range

Barriers to avian flight are usually generated by railways and highways thereby reducing important habitats available to bird species (Jackson, 2000). Birds can easily lose possibility of gaining access to vital habitats once flights are confined to a particular locality.

Breakup in Inhabitant's Population and Segregation

Construction of rail tracks and roads generates obstacles to flight, which divide further bird's population. Resulting to extinctions of restricted population due to inbreeding, and demographic occurrence, ecological changeability and natural catastrophes (Jackson, 2000). Lesser population are more liable to extinction for example population produced from fragmented habitat, because little and extremely isolated population are more vulnerable to genetic modification resulting to inbreeding depression.

Interruption in Regional Populations Maintenance Proceedings

Scattering of bird's population within populations has a negative effect in terms of sustaining and safeguarding genetic differences inside local populations. Apart from that, it may affect the rate of upholding restricted local population and result to extinctions of local population. Within local population, dispersal is very essential for sustain gene flow, augmenting little or reducing population (Jackson, 2000).

HOW CAN THREATS CAUSED BY LAND TRANSPORT IN RURAL AND TOWN LANDSCAPE TO BIRD SPECIES BE MINIMIZED?

The following measures could be adopted to reduce the threats caused by land transport in rural and town landscape are:

- i. Vulnerability of birds to disturbance differs with season for instance rainy season falls into the breeding period of some bird species which coincided with the period when bird's pledges and defend their home range to stimulate fledging and dispersal of young ones. In migratory birds, the period of movement is also important because stopover habitat serves as sources of food for migrating species. Construction of new roads and railways, and maintenance of already existing once should not be schedule during this period because it may reduce visibility and increase threats (such as noise and dust) that are capable of affecting birds. Apart from that, continuous disturbance affects ground nesting birds resulting to nest abandonment coupled with eggs and young ones expose to high threat of being squeeze by vehicles.
- ii. Mowing should be done less frequently or after breeding period is over to safeguard birds that are laying eggs.
- iii. Building of new roads and railways or upgrading of old ones close to roosting and nesting sites should be avoided.
- iv. Flight diverters should be installation to cut down the rate of vehicle collision with birds especially species with rapid flight.
- v. Speed of traffic volume should be reduced to minimize the impact of collision on birds for instance birds that utilizes the ground level (ground-dwelling) or those that fly at night (nocturnal birds), although, this is tough to put into practice some times.
- vi. Reduction in noise generated by road and vehicle using vegetation because vegetation has ability to engross sound produced with respect to its relative density. Planting trees closely together can cut down the rate of noise dissemination.
- vii. Avoidance of attracting birds to roadsides using proper management such as avoidance of planting trees that are less attractive to birds for example trees that could serves as good source of food and nesting materials should be avoided. Apart from that

regular pruning of trees and mowing could render grasses less attractive.

- viii. Reduction in sands and salts utilized by birds from the road side and the use of snow removing agents using ice-detecting technology on surfaces that are not vegetative surface.
- ix. Road killed carcasses, should be removed immediately to prevent it from attracting scavenging birds.
- x. Continuous discouragement of artificial lighting and reflective posts should be adopted.

REFERENCES

- Astudillo PX, Gabriela Samaniego MP, Machado J, Aguilar JM, Tinoco BA, Graham H, Latta SC, Farwig N (2014). The impact of roads on the avifauna of páramo grasslands in Cajas National Park, Ecuador, *Studies on Neotropical Fauna and Environment* 49,204-212.
- Bowgen, K. and Cook, A. 2018. Bird Collision Avoidance: Empirical evidence and impact assessments' Report No.614, JNCC, Peterborough, ISSN 0963-8091.
- Cooke S. C., Balmford A., Donald P.F., Newson S.E. and Johnston A. (2020). Roads as a contributor to landscape-scale variation in bird communities *Nature Communications* (2020) 11:3125, <https://doi.org/10.1038/s41467-020-16899-x>.
- Cooke, S.C. (2020). How bird life may be affected by roads – and what to do about it <https://theconversation.com/how-bird-life-may-be-affected-by-roads-and-what-to-do-about-it-142039>.
- Curry, C.M., Des Brisay, P.G., Rosa, P. & Koper N. (2018b). Noise source and individual physiology mediate effectiveness of bird songs adjusted to anthropogenic noise. *Scientific Reports*, 8(1), 3942. DOI: 10.1038/s41598-018-22253-5.
- Erritzoe J, Mazgajski TD, Rejt Ł. (2003). Bird casualties on European roads — a review. *Acta Ornithol* 38:77–93 <http://www.bioone.org/doi/full/10.3161/068.038.0204>.
- Forman, R. T. T., D. Sperling, J. A. Bissonette, A. P. Clevenger, C. D. Cutshall, V. H. Dale, L. Fahrig, R. France, C. R. Goldman, K. Heanue, J. A. Jones, F. J. Swanson, T. Turrentine, T. C. Winter. 2003. Road ecology: Science and solutions. Washington DC: Island Press; (not paginated), 481 p.

- Ge C, Li Z, Li J, Huang C (2011). The effects on birds of human encroachment on the Qinghai–Tibet Plateau. *Transport Res D-Tr E* 16:604–606. <https://doi.org/10.1016/j.trd.2011.08.003>.
- Glista DJ, DeVault TL, DeWoody JA (2009) A review of mitigation measures for reducing wildlife mortality on roadways. *Landsc Urban Plan* 91:1–7. <https://doi.org/10.1016/j.landurbplan.2008.11.001>.
- Heikki, H. (2001). Impacts of highway construction and traffic on a wetland bird community, *ICOET 2001 Proceedings*, 369-372. <https://escholarship.org/uc/item/3ts9d194>.
- Hell P, Plavý R, Slamečka J, Gašparík J (2005) Losses of mammals (Mammalia) and birds (Aves) on roads in the Slovak part of the Danube Basin. *Eur J Wildl Res* 51:35–40. <https://doi.org/10.1007/s10344-004-0068-6>.
- Heske EJ (2015) Blood on the tracks: track mortality and scavenging rate in urban nature preserves. *Urban Nat* 4:1–13 <https://www.fws.gov/migratorybirds/pdf/management/jacobsen2005highwaymeasures.pdf>
- Injaian, A.S., Taff, C.C., Pearson, K.L., Gin, M.M.Y., Patricelli, G.L. & Vitousek M.N. (2018). Effects of experimental chronic traffic noise exposure on adult and nestling corticosterone levels, and nestling body condition in a free-living bird. *Hormones and Behavior*, 106, 19–27. DOI: 10.1016/j.yhbeh.2018.07.012.
- Jackson, S.D. 2000. Overview of Transportation Impacts on Wildlife Movement and Populations. Pp. 7-20 In Messmer, T.A. and B. West, (eds) *Wildlife and Highways: Seeking Solutions to an Ecological and Socio-economic Dilemma*. The Wildlife Society.
- Jacobson, S.L. (2005). Mitigation Measures for Highway-caused Impacts to Birds, *USDA Forest Service Gen. Tech. Rep. PSW-GTR-191*.
- Jaeger JAG, Bowman J, Brennan J, Fahrig L, Bert D, Bouchard J *et al* (2005) Predicting when animal populations are at risk from roads: an interactive model of road avoidance behavior. *Ecol Model* 185:329–348. <https://doi.org/10.1016/j.ecolmodel.2004.12.015>.
- Johnson, M. D. (2007). Measuring Habitat Quality: A Review the Condor, *the Cooper Ornithological Society*, 109:489–504.
- Kajzer-Bonk, J., Skórka, P., Bonk, M., Lenda, M., Rozej-Pabijan, E., Wantuch, M., and Moroń, D. (2019). The effect of railways on bird diversity in farmland, *Environ Sci Pollut Res*.26:31086–31098.
- Laurance, S. G. W., Stouffer, P. C. and Laurance, W. F. (2004). Effects of road clearings on movement patterns of understory rainforest birds in Central Amazonia. *Conserv. Biol.* 18, 1099–1109.
- Laurance, W. F. et al. (2014). A global strategy for road building. *Nature* 513, 229–232.
- Li Z, Ge C, Li J, Li Y, Xu A, Zhou K, Xue D (2010) Ground-dwelling birds near the Qinghai–Tibet highway and railway *Transport Res D-TrE* 15:525–528. <https://doi.org/10.1016/j.trd.2010.07.004>.
- McKinney, M. L. and Lockwood, J. L. Biotic homogenization: a few winners replacing many losers in the next mass extinction. *Trends Ecol. Evol.* 14, 450–453 (1999).
- Monroe, M. J., Butchart, S. H. M., Mooers, A. O. and Bokma, F. The dynamics underlying avian extinction trajectories forecast a wave of extinctions. *Biol. Lett.* 15, 20190633 (2019).
- Moroń D, Skórka P, Lenda M, Rozej-Pabijan E, Wantuch M, Kajzer-Bonk J, Tryjanowski P. (2014) Railway embankments as new habitat for pollinators in an agricultural landscape. *PLoS ONE* 9: e101297. <https://doi.org/10.1371/journal.pone.0101297>.
- Mumme, R. L., S. J. Schoech, G. E. Woolfenden, and J. W. Fitzpatrick. 2000. Life and death in the fast lane: Demographic consequences of road mortality in the Florida Scrub-Jay. *Conservation Biology* 14 (2): 501–512.
- Naguib M. and Riebel K. (2014). Singing in space and time: the biology of birdsong in: Witzany G., editor. *Biocommunication of animals* Dordrecht (The Netherlands) Springer. p. 233 – 247.
- Palomino D, Carrascal LM (2007) Threshold distances to nearby cities and roads influence the bird community of a mosaic landscape. *Biol Conserv* 140:100–109.
- Parris, K. M. and Schneider, A. (2009). Impacts of traffic noise and traffic volume on birds of roadside habitats. *Ecol. Soc.* 14.

- Pocock Z, Lawrence RE (2005) How far into a forest does the effect of a road extend? Defining road edge effect in eucalypt forests of South–Eastern Australia. In: Irwin CL, Garrett P, McDermott KP (eds) Proceedings of the 2005 International Conference on Ecology and Transportation. Center for Transportation and Environment, North Carolina State University, Raleigh, pp 397–405.
- Polak, M., Wiaćek J., Kucharczyk M. and Orzechowski R. (2013). The effect of road traffic on a breeding community of woodland birds *Eur J Forest Res* (2013) 132:931–941 DOI 10.1007/s10342-013-0732-z.
- Rao, S. & Koli V.K. (2017). Edge effect of busy high traffic roads on the nest site selection of birds inside the city area: Guild response. *Transportation Research Part D: Transport and Environment*, 1, 94–101. DOI: 10.1016/j.trd.2016.12.013.
- Rheindt, F. E. (2003). The impact of roads on birds: does song frequency play a role in determining susceptibility to noise pollution? *J. Ornithol.* 144, 295–306.
- Ryan, M. J. and Brenowitz, E. A. (1985). The role of body size, phylogeny, and ambient noise in the evolution of bird song. *Am. Nat.* 126, 87–100.
- Rytwinski T, Fahrig L (2013). Why are some animal populations unaffected or positively affected by roads? *Oecologia* 173, 1143–1156.
- Santos, S. M. *et al.* (2016). Avian trait-mediated vulnerability to road traffic collisions. *Biol. Conserv.* 200, 122–130.
- Summers, P.D., Cunnington, G.M. & Fahrig L. (2011). Are the negative effects of roads on breeding birds caused by traffic noise? *J. Appl. Ecol.*, 48(6), 1527–1534. DOI: 10.1111/j.1365-2664.2011.02041.x.
- Yrjölä RA, Santaharju JLM (2015). The impact of road construction on a community of farmland birds, *Ann. Zool. Fennici* 52,33-44.



This work is licensed under a [Creative Commons Attribution-NonCommercial 4.0 International License](https://creativecommons.org/licenses/by-nc/4.0/)