Title
Impacts of highway construction and traffic on a wetland bird community

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IMPACTS OF HIGHWAY CONSTRUCTION AND TRAFFIC ON A WETLAND BIRD COMMUNITY

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Abstract: Here I report the ecological impact assessment of a section of European Highway E18 east in Helsinki, Finland. This two-lane section of highway was constructed through the shore pastures of the Pernajanlahti Bay, which is one of the most important nature conservation areas on the southern coast of Finland. It is a wetland area characterized by extensive shore meadows and reed swamps offering habitats to a diverse and abundant birdlife. Wetland bird populations in the target area as well as in a control area were monitored before, during, and after the road construction. The results indicated that after the highway had been opened for traffic, the mean conservation value of the wetland bird community in the target area had decreased by 25 % as compared with the control area. The decline in conservation value was mainly due to the loss of several habitat specialist species, such as European bittern (*Botaurus stellaris*), ruff (*Philomagnus pugnax*) and little gull (*Larus minutus*). Abundance of breeding wader birds also declined in areas near the highway, where the traffic noise level exceeded 56 dB, but did not change much in areas with lower noise load. In contrast to wader birds, population abundance of passerine birds did not show any directional response to disturbance by the highway, regardless of noise level. Despite the negative effects of the highway on conservation value and on many bird populations in the Pernajanlahti Bay, the highway is currently being expanded with another two-lane roadway. The effects of traffic noise could be to some extent mitigated by noise barriers.

Introduction

Environmental impact assessment (EIA) is currently part of the road design process in Finland. However, when the Highway 7, which is part of the international Highway E18, was planned along the southern coast of Finland, no ecological assessment of the alternative routes was implemented. Therefore, the route chosen for the two-lane section of this highway 70 km east of Helsinki was taken through the shores of a wetland nature reserve with high conservation value. This area, the Pernajanlahti Bay, is protected mainly due to its abundant and diverse bird community where wetland birds are especially well represented.

Here I report on preliminary results of a post-project analysis (PPA) of ecological impacts (Wathern 1992) of the construction of the highway on the bird populations of the wetland area. In addition to their conservation value in this area, birds were chosen as the target taxon because they are particularly useful indicators of the ecological state of the environment in which they live (Furness & Greenwood 1993). This is partly due to the fact that the habitat and other ecological requirements as well as population status of most European bird species are well known (Tucker & Heath 1994) and bird monitoring methods are well-developed (Bibby et al. 2000).

Study Areas and Methods

Pernajanlahti Bay (the target area) is one of the most valuable nature conservation areas on the southern coast of Finland. It is characterized by shallow brackish water with submerged vegetation surrounded by extensive reed swamps and shore meadows. The highway was built through the shore pastures on the northern edge of the Bay.

Wetland and marshland bird populations in the Pernajanlahti Bay were monitored by standard bird census methodology (Koskimies & Väisänen 1991). Bird censuses were conducted before the road was built, during the construction, and after the highway had been opened for traffic. The number of monitoring years before, during and after the road construction were two, one and two, respectively. At the same time bird populations were monitored with similar methods in the control area, which is situated about 20 km from the target area. Habitats and bird species composition in the control area (Pieni Pernajanlahti Bay) were very similar to the target area. Possible changes in bird populations as well as in conservation value and diversity of the bird communities in the two areas were compared. Furthermore, changes in bird abundances in the target area were related to the level of traffic noise (Lahti 1994).

The index of conservation value of the bird community is based on species-specific indices of population size, species endangerment, and rarity in the particular biogeographical area in question. It was calculated separately for the two years of each period, i.e. before and after the road construction. Hence it is a

comparable value for comparison between the two periods. Factorial analysis of variance (ANOVA) and repeated measures ANOVA (Zar 1996) were used for the statistical analysis of the data. Prior to the analyses the data were $\log_{10}$-transformed.

Results

Conservation value

Road construction caused habitat changes and disturbance, and traffic noise accounted for extra disturbance. The mean conservation value of the wetland bird community in the target area declined by 25 % as compared with the control area after the highway had been opened for traffic. This reduction is derived from 23.3 % reduction in the target area (from 79.5 ± 3.5 to 61 ± 5.6 points) and 2.4 % increase in the control area (from 60.5 ± 6.4 to 62 ± 1.4 (mean ± SD)) over the same period of time. This difference in the change of the mean conservation value through time in the two areas was statistically significant (ANOVA, interaction between period and noise level, $F_{1,4} = 9.195$, $P = 0.039$). Much of the decline in conservation value in the target area was due to the loss of several habitat specialist species with high conservation value, such as European bittern (*Botaurus stellaris*), marsh harrier (*Circus aeruginosus*), crane (*Grus grus*), ruff (*Philomachus pugnax*) and little gull (*Larus minutus*) during and after the road construction. These species are restricted to wetland and marshland habitats and all but marsh harrier have declining population trends in Europe (Tucker & Heath 1994).

Population changes of waders and passerines

The abundance of wader birds breeding in the shore meadows near the highway (up to 200 meters) dropped by 50 % during the road construction and the decline was almost 80 % after the highway had been opened for traffic (Fig. 1). Farther off from the highway the decline in the wader populations was less steep and it leveled off when the distance from the road was more than 800 meters (Fig. 1). In addition to habitat destruction, the

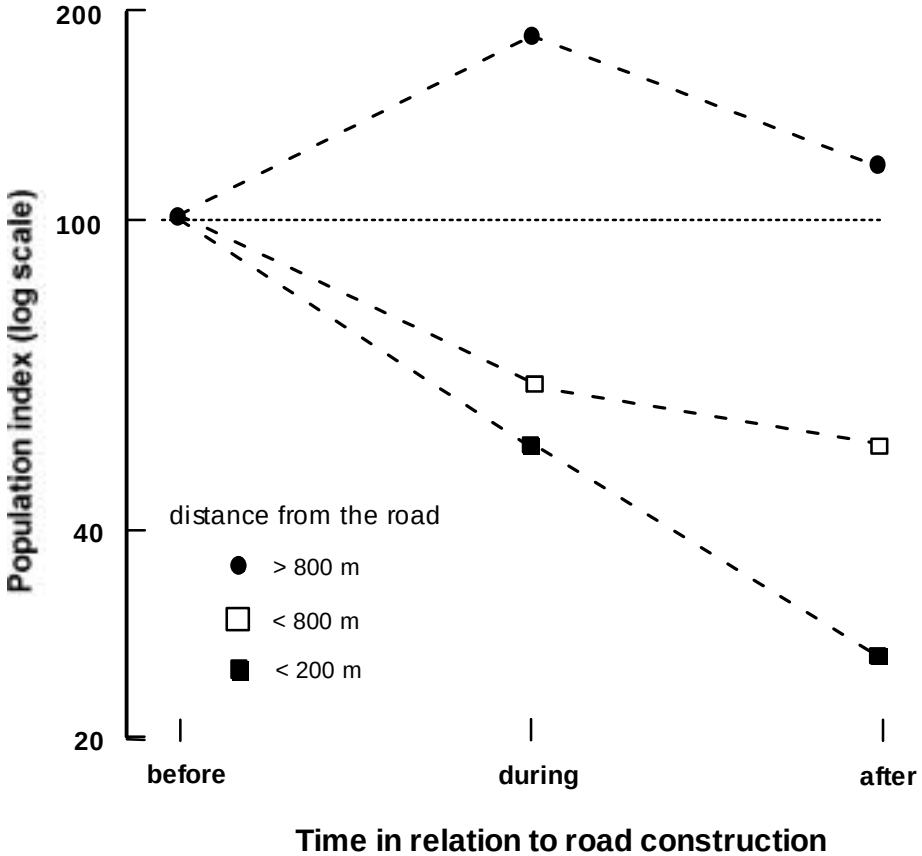

Fig. 1. Changes in population index (log scale) of breeding waders in relation to the distance (in meters) of from the highway before (index value 100), during and after the construction.

main reason for the severe decrease in the number of breeding waders near the highway was probably traffic noise. This is demonstrated when wader populations are compared before and after the highway was opened for traffic in the zones where traffic noise was more than 56 dB and less than 56 dB (Table 1). In the zone where traffic noise was > 56 dB, the number of breeding waders declined, whereas in areas where traffic noise was < 56 dB wader abundance remained fairly constant (Table 1). The wader population changes in the two noise zones were significantly different from each other (Table 1; repeated measures ANOVA, interaction between period and noise level, $F_{1,8} = 5.434$, $P = 0.048$).

On the contrary, the passerine birds breeding in the meadows did not show any clear responses to the highway and traffic noise (Table 1). Therefore, there was no significant difference in the population trends in the two traffic zones (Table 1; $F_{1,4} = 0.156$, $P = 0.713$). Thus, passerine birds seemed to be less vulnerable to disturbance caused by road construction and traffic disturbance than waders.

Table 1
Population indices of waders and passerines in the zones of traffic noise load of > 56 dB and < 56dB before and after the highway (see text for details).

	Noise load	> 56 dB	< 56 dB
Waders	before	100	100
	after	38	100
Passerines	before	100	100
	after	90	105

Discussion

Reduction in wader populations

The results of this long-term monitoring study indicate that habitat changes and disturbance caused by road construction and traffic noise had considerable effects on breeding populations of waders, while passerine populations showed minor responses. In the open shore meadows, through which the highway was built, the number of breeding wader birds declined considerably due to the highway and the consequent increased disturbance to the distance of 800 m. Although it is not possible to tell apart the effects of habitat changes and traffic noise completely, it is probable that the latter factor was more important here. This finding is in accordance with the results reported by van der Zande et al. (1980). They found that road traffic reduced the densities of the waders lapwing (*Vanellus vanellus*) and black-tailed godwit (*Limosa limosa*) up to two kilometers away from the road in open field habitats.

Similar results have been demonstrated by correlative studies in the Netherlands. For example, in a study based on regression between traffic load and bird densities, Reijnen et al. (1996) showed that out of the four wader species studied, three species showed a decrease in density adjacent to the road. Disturbance distance caused by traffic load for Oystercatcher (*Haematopus ostralegus*) was found to be as high as 3000 m along roads with high traffic densities (50,000 cars per day). In the Pernajanlahti Bay the traffic density was approximately from 15,000 to 20,000 cars per day, and therefore the disturbance distance for the wader species was probably found to be most significant up to 200 meters, though clear disturbance effects were found up to 800 m away from the highway.

No directional change in passerine populations

In the present study waders responded to the highway and traffic noise, but passerine species showed no effect. Earlier studies have also shown a similar difference between these groups of birds. For example, Haworth and Thompson (1990) found that many wader species avoided areas with strong human disturbance, but the occurrence of passerine birds was more clearly related to habitat quality than to human disturbance. However, the response to traffic noise and other disturbance caused by roads and their construction can vary depending on the bird species (e.g., Ferris 1979). In fact, in the abovementioned study Reijnen et al. (1996) found that passerines skylark (*Alauda arvensis*) and meadow pipit (*Anthus pratensis*), which breed in open landscapes, also suffered from disturbance by traffic. Their disturbance distances were roughly half of that of the wader species. Both species also occur in the shore meadows of the Pernajanlahti Bay, but because of low breeding densities and short disturbance distance, no significant effect of the car traffic was observed in this study.

Mechanisms of traffic disturbance

One finding of the present study was that the bird species specialized in wetland habitats proved to be most vulnerable to disturbance. For example, territories of European bitterns used to be located in the reed beds considerably far off from the road line. Therefore, habitat changes probably had no effect on their disappearance, but disturbance by car traffic is the most probable reason. Bittern males attract females by a deep and loud mating call. Frequency range of the call (Cramp & Simmons 1977) is similar to the most dominant part of the traffic noise spectrum in the Pernajanlahti Bay area (Lahti 1994). In the areas where the bittern territories were located before the highway the level of the traffic noise is now about 53-55 dB in the summertime (Lahti 1994), which exceeds the loudness of the mating call by male bittern (40 dB; Cramp & Simmons 1977). This means that bittern mating calls are masked by the traffic noise and remain inaudible for the females, and maybe therefore the males abandoned the area.

Mitigation of disturbance

On the basis of this study, extra care should be taken in planning new roads in open wetland areas. Despite the fact that the present highway has been shown to have negative effects on conservation value and on many bird populations in the Pernajanlahti Bay, the highway is currently being expanded with another two-lane roadway. From a conservation point of view, it is also important to explore how the present effects could be reduced. As the most severe disturbance here is caused by traffic noise, it seems that noise barriers could be used to mitigate the existing disturbance.

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