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Landscape-scale impacts of transportation infrastructure on spatial dynamics of two vulnerable ungulate species in Ghamishloo Wildlife Refuge, Iran

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ABSTRACT

Development of roads through protected areas can have deleterious effects on natural habitats containing species of conservation concern. During the past decades road construction has affected many former remote areas and led to fragmentation and isolation of wildlife populations. The present study focuses on the ecological impacts of Isfahan's West Freeway, which passes through Ghamishloo Wildlife Refuge; an IUCN category IV protected area, in Isfahan Province. The two key affected species, both classified as vulnerable by IUCN, the goitered gazelle (*Gazella subgutturosa subgutturosa*) and the wild sheep (*Ovis orientalis isphahanica*) were subject to impact analyses. We used habitat evaluation procedure (HEP) as a habitat-based impact assessment methodology which considers habitat quality and quantity. Habitat quality was measured as habitat suitability index (HSI) for each species. By literature review and field observations, five variables defining habitat suitability were identified and suitability maps for both species generated. Habitat units (HUs) were derived from multiplying the HSI for each species by the habitat area before and after freeway construction. The results showed that due to the construction of the freeway, about 14% of the HUs for goitered gazelle and about 9% of the HUs for wild sheep were lost. In addition, for quantifying landscape pattern change due to freeway construction, various landscape metrics were calculated for the species distribution polygons for two times before and after freeway construction. Results obtained through quantifying landscape metrics showed that mean nearest neighbor (MNN) and number of patches (NP) metrics increased. On the other hand, CONTAG metric decreased in both goitered gazelle and wild sheep distribution polygons, demonstrating the negative effect of freeway on these species distribution polygons integrity. According to the results of this study, mitigation and compensation activities should be considered in Ghamishloo Wildlife Refuge. Our study demonstrated that HEP method combined with quantifying landscape metrics might provide a powerful tool for assessing ecological impact of technical infrastructures on populations of far-ranging species of conservation concern.

1. Introduction

Modern human-dominated environments are subject to frequent and intense environmental perturbations (Mcdonald et al., 2009). Transportation infrastructure that enhances connectivity among human settlements often results in decreased connectivity among remaining natural habitats and wildlife populations (Forman and Alexander, 1998). Habitat fragmentation and the creation of barriers by transportation infrastructures reduce landscape connectivity, which is suspected to be one of the most important factors causing wildlife population declines (Borda-de-Água et al., 2011; Forman et al., 2003). Road networks affect wildlife habitats in different ways. First, road construction directly leads to a habitat loss. Second, maintenance and use of roads reduce habitat quality for wildlife by increasing distance between remaining habitat patches (Goodwin and Fahrig, 2002), and via additive barrier and mortality effects (Ascensao and Mira, 2006; Eigenbrod et al., 2008; Hoskin and Goosem, 2010; Jaeger et al., 2005; Shepard et al., 2008). This may hamper dispersal, which is critical for the long-term population viability of wildlife species (Debinski and Holt, 2000; Laurance et al., 2002; Lienert, 2004). By altering habitat area and spatial distribution of habitat patches, road networks affect the structure and spatial heterogeneity of a landscape. Development of roads in protected areas and ecological sensitive regions can have deleterious effects on wildlife populations (Lian et al., 2011). In addition to these primary impacts, roads may also provoke

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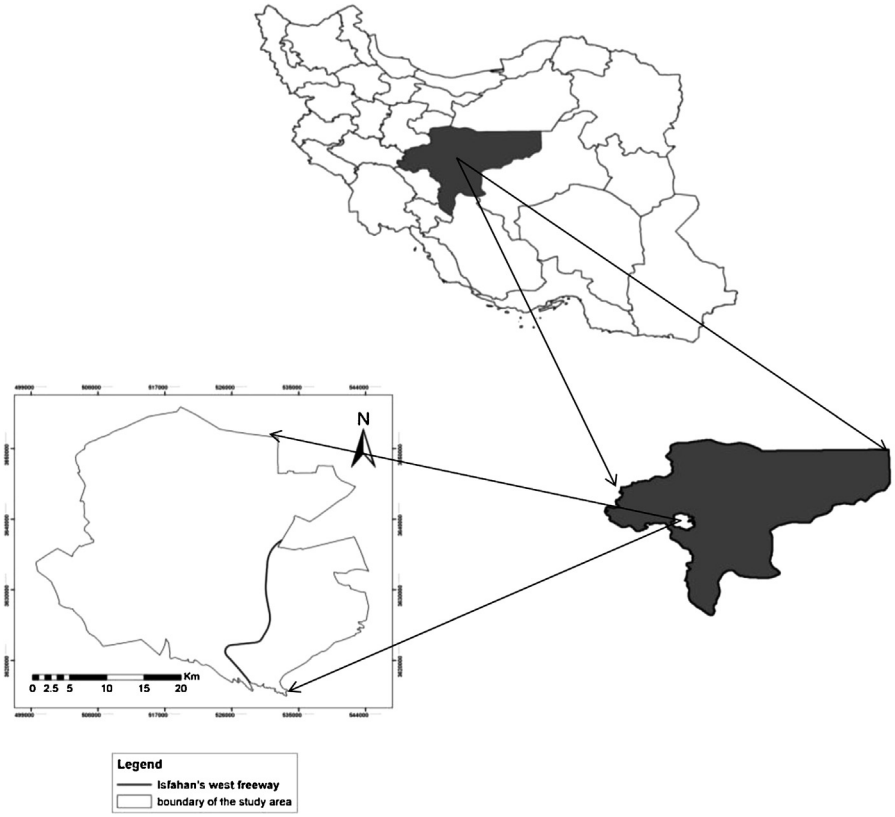

Fig. 1. Study area.

various secondary effects on protected areas. They may facilitate access to hunters, poachers and uncontrolled tourism (Gratson and Whitman, 2000). In addition new roads commonly promote economic development which may compromise conservation goals.

Far-ranging mammals such as large herbivores are particularly sensitive to habitat fragmentation because they need unrestricted access to large continuous habitat (Bolger et al., 2008). Fragmentation of habitat into small, non-contiguous patches may result in dramatic population declines (Simmons et al., 2010). Furthermore, small and isolated subpopulations are Eigenbrod et al., 2008; vulnerable to demographic, genetic, and environmental stochasticity (Fahrig, 2003).

Not withstanding these negative ecological impacts, road networks grow and get denser worldwide due to increasing socio-economic needs for high mobility (Coffin, 2007; Shanley and Pyare, 2011). In Iran, road construction in ecologically sensitive habitats, i.e. protected areas and national parks, has been increasing during the past decades and ecological impacts have become highly visible (Momen Bellah Fard, 2009; Monavari and Mirsaeed, 2008).

In most cases, the ecological value of existing wildlife habitat has been considered of secondary importance in the face of compelling economic and social arguments for road construction. Assessment of ecological impacts of road construction is commonly hampered by a lack of appropriate data. Thus appropriate studies quantifying habitat loss and landscape pattern changes are essential. Further, there is a lack of studies on their impacts on animal species distribution and migration.

Here we provide quantitative data on habitat loss and landscape fragmentation due to Isfahan's West Freeway, which passes through Ghamishloo Wildlife Refuge, I.U.C.N category IV, Habitat/Species Management Area, in Isfahan Province of Iran. The two key affected species in the study area were goitered gazelle (*Gazella subgutturosa subgutterosa*) and wild sheep (*Ovis orientalis isphahanica*), both classified as Vulnerable (VU) on the IUCN Red List (Mallon, 2008; Valdez, 2008). The following questions were investigated in this study:

(1) How did habitat changes due to road construction affect the distribution of goitered gazelle and wild sheep?
(2) How does an existing freeway affect habitat quality and quantity of the large herbivores in Ghamishloo Wildlife Refuge?
(3) How landscape metrics such as MNN (mean nearest neighbor); NP (number of habitat patches) and degree of landscape fragmentation have been changed due to road disturbance effects?

2. Materials and methods

2.1. Study area

Our study area, Ghamishloo Wildlife Refuge is located 45 km northwest of Isfahan City, Iran (Fig. 1). Ghamishloo is located at 50°59′43″ to 51°28′09″ eastern longitude and 32°40′05″ to 33′02′24″ northern latitude and covered an area of approximately 113′653 ha. This area is covered with plains, mountains and rolling hills. The climate in this region is semi-arid and continental, with average temperatures ranging from −18.5 to 41.5 °C (hot dry summers, and cold dry winters), and mean annual precipitation of 180–190 mm.

The lowest elevation of the area is 1687 m above sea level in the southern part of the region. The bedrock mainly consisted of various sediments of Quaternary and Mesozoic age. Vegetation cover is sparse in the valleys and increases at the higher elevations. The vegetation of the area is typical drought tolerant shrub-steppe communities including *Artemisia* sp., *Astragalus* sp., Asteraceae, Brassicaceae, Poacea and etc. The area benefits from a naturally diverse terrain resulting in a rich fauna and flora. In total, more than