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Research article

Green infrastructure development at European Union's eastern border: Effects of road infrastructure and forest habitat loss

Per Angelstam [a, *], Olha Khaulyak [a], Taras Yamelynets [a, b, c], Gintautas Mozgeris [d], Vladimir Naumov [a], Tadeusz J. Chmielewski [e], Marine Elbakidze [a], Michael Manton [a, f], Bohdan Prots [c, g], Sviataslau Valasiuk [h]

[a] Swedish University of Agricultural Sciences, Faculty of Forest Sciences, School for Forest Management, Forest-Landscape-Society Network, PO Box 43, SE-739 21 Skinnskatteberg, Sweden
[b] Ivan Franko National University, Faculty of Geography, Doroshenko Street 41, 79000 Lviv, Ukraine
[c] WWF Danube Carpathian Programme, Mushaka Street 42, 79000 Lviv, Ukraine
[d] Aleksandras Stulginskis University, Institute of Forest Management and Wood Science, Studentų 13, LT-53362 Akademija, Kauno r., Lithuania
[e] University of Life Sciences in Lublin, Department of Landscape Ecology and Nature Conservation, Dobrzańskiego St. 37, 20-262 Lublin, Poland
[f] Aleksandras Stulginskis University, Institute of Forest Biology and Silviculture, Studentų 13, LT-53362 Akademija, Kauno r., Lithuania
[g] National Academy of Sciences of Ukraine, State Museum of Natural History, 18 Teatralna Street, Lviv 79008, Ukraine
[h] National Academy of Sciences of Belarus, Centre of Biological Resources, Department of Wildlife Conservation, Akademicheskaya Street 27, 220072 Minsk, Belarus

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ABSTRACT

The functionality of forest patches and networks as green infrastructure may be affected negatively both by expanding road networks and forestry intensification. We assessed the effects of (1) the current and planned road infrastructure, and (2) forest loss and gain, on the remaining large forest landscape massifs as green infrastructure at the EU's eastern border region in post-socialistic transition. First, habitat patch and network functionality in 1996–98 was assessed using habitat suitability index modelling. Second, we made expert interviews about road development with planners in 10 administrative regions in Poland, Belarus and Ukraine. Third, forest loss and gain inside the forest massifs, and gain outside them during the period 2001–14 were measured. This EU cross-border region hosts four remaining forest massifs as regional green infrastructure hotspots. While Poland's road network is developing fast in terms of new freeways, city bypasses and upgrades of road quality, in Belarus and Ukraine the focus is on maintenance of existing roads, and no new corridors. We conclude that economic support from the EU, and thus rapid development of roads in Poland, is likely to reduce the permeability for wildlife of the urban and agricultural matrix around existing forest massifs. However, the four identified forest massifs themselves, forming the forest landscape green infrastructure at the EU's east border, were little affected by road development plans. In contrast, forest loss inside massifs was high, especially in Ukraine. Only in Poland forest loss was balanced by gain. Forest gain outside forest massifs was low. To conclude, pro-active and collaborative spatial planning across different sectors and countries is needed to secure functional forest green infrastructure as base for biodiversity conservation and human well-being.

1. Introduction

Biodiversity conservation is a contemporary challenge to a wide range of societal sectors that affect land use and land cover change. The main vision for the conservation of forest and woodland ecosystems' composition, structure and function (Noss, 1990) in Europe is linked to the concept of naturalness (Peterken, 1996). This vision implies that natural processes operate, and are allowed to maintain representative functional networks of different forest and

* Corresponding author.
E-mail addresses: per.angelstam@slu.se (P. Angelstam), okhaulyak@gmail.com (O. Khaulyak), taras.yamelynets@gmail.com (T. Yamelynets), gintautas.mozgeris@asu.lt (G. Mozgeris), vladimir.naumov@slu.se (V. Naumov), tadeusz.chmielewski@up.lublin.pl (T.J. Chmielewski), marine.elbakidze@slu.se (M. Elbakidze), michael.manton@slu.se (M. Manton), bohdan.prots@gmail.com (B. Prots), sviatsviat@gmail.com (S. Valasiuk).

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woodland habitats at multiple spatial scales so that species may survive in viable populations (e.g., Angelstam et al., 2011a). Additionally, human management in pre-industrial agroforestry systems such as practised in traditional village systems (Elbakidze and Angelstam, 2007), provide habitat for species which do not thrive in intensively managed forest landscapes. In spite of increasing responses to cope with biodiversity loss, the state of green infrastructure continues to deteriorate as land use and management pressures increase (Butchart et al., 2010). Anthropogenic alteration, fragmentation and loss of natural forests and woodlands stand out as key reasons behind the creation of policies aimed at biodiversity conservation (e.g., Donald et al., 2001). From a spatial planning point-of-view the key to biodiversity conservation is to maintain sufficient quality, size, amount and connectivity of patches representing natural forests and cultural landscapes so that they form functional habitat networks, also termed ecological networks (e.g., Jongman, 1995), or green infrastructure (European Commission, 2013). Green infrastructure emphasizes the functional interconnection of sufficient amounts of natural and semi-natural ecosystems where patches of green space, protected areas, parks and recreation sites are constituent parts. This requires land stewardship through territorial planning, combined with operational conservation, management, restoration and re-creation, to maintain sufficient amounts of representative land cover types that exceed evidence-based conservation targets (e.g., Groves et al., 2002; Angelstam et al., 2011a).

In Europe the states and trends of biodiversity differ considerably among regions. Generally, the intensity of natural resource use is higher in the west than in the east (Gunst, 1989; Angelstam et al., 2011b). As a consequence, the composition, structure and function of natural ecosystems are more altered in Europe's west than in Europe's east (Angelstam and Dönz-Breuss, 2004; Puumalainen et al., 2002, 2003). Thus, a wide range of species have better habitat conditions outside the European Union (EU) and in new EU member states, than in old ones (e.g., Donald et al., 2001, 2002; Roberge et al., 2008; Edman et al., 2011; Kaczensky et al., 2012). Large areas of functionally connected forests and woodlands (i.e. forest landscape massifs) in mountain, wetland and authentic cultural landscapes are still found just outside the EU in the Carpathian ecoregion (Borsa et al., 2009; Angelstam et al., 2013), Belarus (Yermokhin et al., 2007) and in the Russian Federation (Yaroshenko et al., 2001).

The expansion of the EU to the east during the period 2004–2013, which resulted in the inclusion of 10 new countries, was associated with several efforts to encourage macro-economic development (Čihák and Fonteyne, 2009). For example, already in 1991 the Polish government signed an agreement which established an associate relationship between the EU and Poland. A key topic was transport infrastructure development (Churski and Ratajczak, 2010). Transport infrastructure development is, however, likely to lead to direct consequences in terms of mortality and barrier effects for individuals of different species (Forman and Alexander, 1998; Hels and Buchwald, 2001), dissection and fragmentation of landscapes' different land covers (Mader, 1984; Kruess and Tscharntke, 1994), and an increased human footprint in terms of intensified land use (e.g., Konvicka et al., 2006). Roadless and low-traffic areas with lower levels of anthropogenic disturbances are of special concern in Europe because of their rarity (Selva et al., 2011). This has led to conflicts concerning road infrastructure and forest conservation and development in Poland (Ziemińska and Szulecki, 2010; Blicharska and Angelstam, 2010). As a response, a nation-wide network of ecological corridors composed mainly of forest and river valleys ecosystems was proposed (Jędrzejewski and Ławreszuk, 2009).

The recent dynamic of forest loss inside forest massifs and gain of forest outside them in Eastern Europe (e.g., Potapov et al., 2015) are two additional factors that may both reduce and improve, respectively, the functionality of the few remaining forest massifs as green infrastructure. The emerging market economy in post-socialistic countries has led to intensified logging (Kuemmerle et al., 2006), as well as abandonment of agricultural land followed by encroaching forest (Baumann et al., 2011). However, the net effect on green infrastructure development is not known. Conservation of green infrastructure thus requires knowledge about the state and trends of both road development and forestry trajectories on the one hand, and consequences for green infrastructure functionality at the regional level on the other (Angelstam et al., 2011a; Orlikowska et al., 2016). Such knowledge is fundamental for evidence-based integrated spatial planning approaches (Pauleit et al., 2010; Blicharska et al., 2011; Grodzinska-Jurczak and Cent, 2011).

The aim of this study is to assess the extent to which expanding road infrastructure, and forest loss and gain, affect forests as green infrastructure for biodiversity conservation and human well-being at EU's eastern border. We focus on the cross-border region of Poland in the EU, as well as Belarus and Ukraine outside the EU. This region forms the core zone of a southwest-northeast gradient from fragmented to contiguous forest landscapes on the European continent. First, we modelled the functionality of forests as green infrastructure for focal species with large area demands (e.g., Mikusiński and Angelstam, 2004). Second, we mapped by interviewing road planners the present state of the road network and current plans for its future development in the cross-border region where the EU, Belarus and Ukraine meet. Third, we measured forest loss and gain inside forest massifs, and gain outside them. To understand whether or not forest massifs as green infrastructure are likely to be negatively affected by transport infrastructure, we compared the existing and planned roads, as well as forest loss and gain affecting the remaining forest massifs. We discuss the current and potential future consequences of the interaction between transport infrastructure and forest loss and gain developments on the one hand, and the functionality of forests as green infrastructure on the other, and how to deal with this proactively.

2. Study system context

2.1. Policies about green infrastructure

The Pan-European Biological and Landscape Diversity Strategy (PEBLS) is a response to support implementation of the Convention on Biological Diversity (Anon, 1992a). To create a Pan European Ecological Network (PEEN) is a major project for the implementation of the PEBLS aiming at conservation and management of species, ecosystems, habitats, and landscapes (Council of Europe, (1996)). The EU Habitats Directive designed to protect the most seriously threatened habitats and species across the Member States (European Union, 1992). This legislation complements the Birds Directive adopted in 1979 (European Union, 1979). To implement this legislation a network of sites called Natura 2000 is being created (Anon, 2009a). This is not restricted to nature reserves, but based on a much broader principle of conservation and sustainable use, where people and wildlife can live together in harmony (Anon, 2009a). The emergence of the ecosystem service concept at the policy level resulted in green infrastructure as a tool to encourage functional networks of natural and semi-natural areas on the ground by spatial planning (European Commission, 2013). The geographic location of the study area and its diverse natural and cultural heritage make this territory one of the key zones of the Pan European Ecological Network (Chmielewski, 1997; Yermokhin et al., 2007).