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THE ACTUAL RELEVANCE OF ECOLOGICAL CORRIDORS IN NATURE CONSERVATION

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Abstract: The paper considers theoretical and applied foundations of the concept of the ecological corridors in nature conservation. Their relevance comes from recent ecological phenomenon of habitat fragmentation which is rapidly increasing during last decades. Habitat fragmentation is one of the main threats to richness and diversity of wildlife. Ecological corridors can mitigate the loss and fragmentation of habitat. Corridors perform as "bridges" between habitats for species and they provide a flow of the natural or even anthropogenic caused disturbances. In this paper we will present the meaning and significance of ecological corridors in nature conservation, as well as types of ecological corridors and their ecological benefits. Methodological and practical approaches in nature protection system in Serbia are included.

Key words: fragmentation, connectivity, ecological corridors, nature protection, Serbia.

Introduction

Main threats to nature conservation today and especially to biodiversity are habitat loss and fragmentation (Bennett, 1999; Henle et al., 2004; Đurđić, 2010). The habitat fragmentation is a transformation of a continuous habitat into habitat patches, i.e. fragments that differs in size and configuration (Fahrig, 2003). First stage in this process is a loss of habitat which is actualy reducing the size of habitat. This often results in breaking the habitat into fragments, i.e. the latter process of fragmentation (Figure 1).

Then, the habitat becomes a mosaic of fragments (patches) in surrounding matrix. Matrix represents various kinds of communities different in all of their physical and biotic dimensions that surround habitat fragments (Hilty et al., 2006). The population that inhabit patches can move over "hostile" matrix over corridors. Habitat loss and fragmentation can have both positive and negative

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impact on biodiversity. They can be caused both by natural or anthropogenic processes. In this paper we will focus on the meaning and the role of ecological corridors in nature protection and conservation.

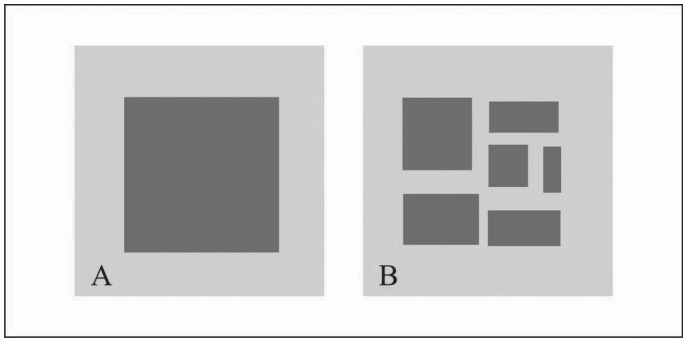

Figure 1. Continuous (A) and fragmented (B) habitat - scheme.

The meaning and significance of ecological corridors in nature conservation is recognized through two main ecological, i.e. biogeographical theories: *the Theory of Island Biogeography*, established by Robert A. Mac Arthur and Edward O. Wilson in 1967, and *the Metapopulation Theory*, established by R. Levins in 1970. Islands have always had a great influence on biogeography. There are plenty of reasons for this: islands and other insular habitats, such as lakes, springs, mountain tops, and caves are ideal subjects for natural experiments. They are relatively simple, defined, numerous, and isolated (Brown & Lomolino, 1998) so they present true natural laboratories.

The Theory of Island Biogeography. According to the theory, it is possible to emphasize two general patters in biogeography of isolated (spatial and functional) areas: the tendencies for the number of species to increase with island area and to decrease with island isolation. With this theory, the concept of a dynamic equilibrium was developed, i.e. that opposing forces maintain constancy in some characteristic of a system despite continual changes or turnover (Brown & Lomolino, 1998). With the expanding of this theory on the variety of insular habitats like mountain tops, lakes, caves, or protected areas as well, capability for reduction of distance effect become more realistic through ecological corridors. Distance effect is equal to isolation effect and for island habitats, isolation effect can be minimized by leaving a corridor of suitable habitat which can facilitate migrations of species. Using the corridors depends on the species, e.g. ecological conditions.

Metapopulation Theory. The term metapopulation was coined by Levins to describe a model of population dynamics of insect pests in agricultural fields, but the theory mainly refers to species in fragmented habitats. The metapopulation theory (Levins, 1970; Hanski, 1994) attempts to evaluate the relation between islands or fragments which must be populated to ensure survival of species population which interacts. The metapopulation is a set of local population which interacts between each other. It is also, a dynamic group of local populations that is in a stochastic equilibrium between local extinctions and colonizations of currently empty land with suitable habitat patches. Human activities and natural disasters are the main causes of increasing the metapopulation phenomenon in nature. According to the biogeographers, corridors are one of the main types of dispersal routes. There are four basic types of dispersal routes based on their effects on biotic exchange (Brown & Lomolino, 1998): I) Corridors (dispersal routes that allow the movement of taxa from one region to another (Simpson, 1940; Udvardy, 1969; Brown & Lomolino, 1998)), II) Filters (dispersal routes that selectively blocks the passage of certain forms while allowing those able to tolerate the conditions of the barrier to migrate freely), III) Sweepstakes routes (chance dispersal from one region to another across a major barrier) and iv) Other dispersal routes (can be formed when a landmass is shifted from one place to another by seafloor spreading).

Definitions and meaning of ecological corridors

During time, a great number of definitions of corridors have been proposed. Some authors defined corridors as routes that enhanced speedy and unselective spread of biota between regions (Perault & Lomolino, 2000). By other definition, corridors are “avenues along which wide-ranging animals can travel, plants can propagate, genetic interchange can occur, populations can move in response to environmental changes and natural disasters, and threatened species can be replenished from other areas” (Walker & Craighead, 1997). Soulé & Gilpin (1991) depicted corridors as linear elements that connect two or more patches of natural habitat and function to facilitate movement. Many European countries develop their own definitions of corridors with emphasis on different objectives and approaches to nature conservation. That is followed by number of synonyms of this term, such as: ecological corridors, habitat corridors, wildlife corridors, biological corridors, etc. The term corridor is used in a variety of ways. Although all these definitions are not incorrect, we will emphasize the definition given by Hilty et al. (2006): "Corridor is any space, usually linear in shape that improves the ability of organisms to move among patches of their habitat".

In Serbia, term ecological corridor is defined in the Law on Nature Conservation (Official Gazette of the Republic of Serbia, nr. 36/2009 & 88/2010) as: "an ecological pathway or connection that permits movement of individuals, populations and genes between protected areas and ecologically important areas from one site to another and it is part of ecological network" The same law defines an ecologically important area as: “a part of an ecological network relevant for conservation of species, certain habitat types and habitats of certain relevant species for the Republic of Serbia" Ecological network is also defined in the Law on Nature Conservation (Official Gazette of the Republic of Serbia, nr. 36/2009 & 88/2010): “Ecological network is a set of functionally connected or spatially closed ecologically important areas, which contribute to biodiversity conservation, including ecologically important areas of European Union Natura 2000 as well” (Figure 2).

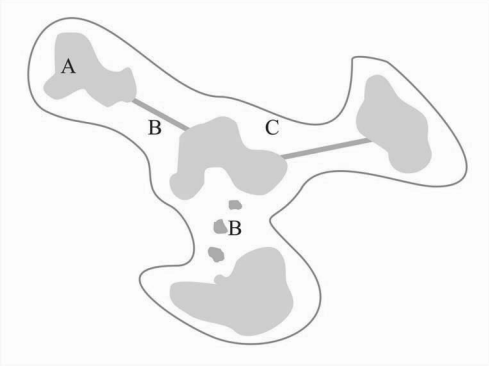

Figure 2. Ecological network – scheme (A – ecologically important area, B – ecological corridors C – buffer zone) (Scheme adopted according to Szabadoš et al., 2011).

According to the Statute on ecological network (Official Gazette of the Republic of Serbia nr. 102/2010) ecological network comprises following: I) ecologically important areas (or core areas); II) ecological corridors which connect ecologically important areas on the territory of the Republic of Serbia, as well as corridors of national significance and ecological corridors which provide connectivity with ecological networks of surrounding countries – international corridors; and III) buffer zone where needed to protect ecologically important areas and ecological corridors of possible negative influence.

Types, significance and functions of ecological corridors

Corridors can be of different spatial levels. On the one side they can reach intercontinental scale like Bering Strait during Pleistocene, or on the other side

they can be small-scale pathways which enhance movement of organisms through dense vegetation or over complicated topographic areas.

There is a distinction between planned and unplanned corridors. Unplanned corridors are landscape elements that facilitate connectivity but exist for other reasons. These are often sites where suitable habitat is left undisturbed, providing a different vegetative structure from the surrounding matrix, such as fencerows, roadside corridors, creeks, shelterbelts, etc. (Hilty et al., 2006). Planned corridors can be planned not only for biodiversity connectivity purpose. For example, greenways can potentially provide connectivity. Planned corridors can be buffering riparian zones, corridors for individual species conservation and corridors that enhance community integrity (Hilty et al., 2006).

The USDA Conservation Corridor Planning at the Landscape Level Handbook (1999) differs corridors in terms of size and type. In terms of size, they are referred to as regional-, watershed-, or farm-size corridors.

- *Regional corridors* connect large areas of diverse ecosystems. These corridors enhance major movement of wild animals, plants and other organisms.
- *Watershed corridors* are usually miles or fractions of miles wide. They enhance movement of wildlife within a watershed.
- *Farm corridors* often only measure hundreds of meters in width, and they enhance movement of localized wildlife.

According to the same reference, we can identify other five different types:

- *Environmental corridors* are undisturbed natural areas, such as those along streams or forested regions.
- *Remnant corridors* are strips of land left after new land uses have been implemented in an area.
- *Introduced corridors* are strips of vegetation planted for conservation purposes, such as to serve as windbreaks, filter strips, or riparian areas.
- *Disturbance corridors* are produced by activities that disturb vegetation in a given strip of land, such as a mowed roadside.
- *Regenerated corridors* result when regrowth occurs in a previously developed area, such as an abandoned road or rail right-of-way.

In morphological terms, there are (Figure 3):

- *Linear corridors* - long, uninterrupted strips of vegetation, such as hedges, strips of forest, and the vegetation growing on banks of rivers and streams;
- *Stepping stone corridors* - series of small, non-connected habitats which are used to find shelter, food, or to rest;

– *Landscape corridors* - consist of diverse, uninterrupted landscape elements which offer sufficient cover for a safe journey from one habitat patch to another.

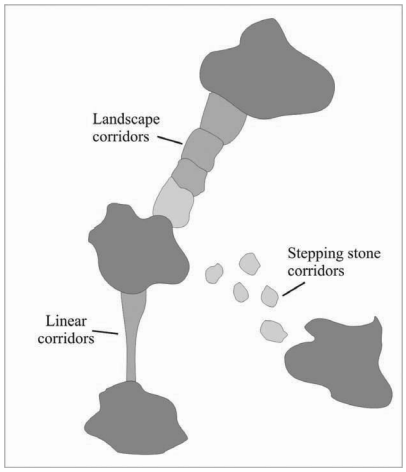

Figure 3. Morphological types of ecological corridors.

Before analyzing the importance and role of ecological corridors we will emphasize some points:

– Corridors can be focused on some or all levels of biodiversity;
– Corridors occur at different spatial levels;
– Corridors can provide connectivity for one species, but for other it can be a barrier due to species' different operational scales and habitat requirements.

Because of the fact that survival of individual species can be affected by integrity of a community, planning for entire community should be considered where possible. In general, ecological corridors can achieve following ecological services: movement and dispersal, overall species persistence, habitat connectivity, genetic exchange, avoiding predation and healthy ecosystem functioning.

Species and populations travel every day from one habitat fragment to another. One of the reasons for daily migration is access to resources, such as water, food, etc. Corridors can provide continuing of migration routes to required resources. For some species it is necessary to maintain corridors in order to keep seasonal and annual migration. For example, pronghorn (*Antilocapra americana*) is migrating up to 270 km between Grand Taton National Park and Red Dessert in Wayoming over route which is used for over six thousand years

(Hilty et al., 2006). Destroying of this route will certainly affect on population dynamics of this species.

In comparison to equivalent fragments of habitat that lack connectivity, corridors can increase overall species' persistence. This can be achieved by assisting in the movement of species among otherwise separate populations. By enhancing migrations of species, corridors may protect groups of small populations from extinction by increasing persistence of species within a given patch. In this way corridors enable recolonization of a habitat fragment after local extinction (Beier & Loe, 1992).

With enhancing the connectivity, dispersal is increasing as well as genetic interchange among wildlife populations, thus reducing the risks of inbreeding depression (Beier & Loe, 1992; Bennett, 1999; Hilty et al., 2006). Dispersal of species can increase levels of genetic variability within populations and thus reduce fixed differences between populations. Even a low level of gene flow will avoid the chance fixation of deleterious genetic traits.

Corridors may also help dispersers to avoid predation or human-caused death in attempting to cross matrix. There are only few studies that document dispersal of wide-ranging species, so evidences of this are still incomplete. Corridors can help withholding healthy functioning ecosystems. Corridors can keep predators in habitat patches, the loss of which can result in a numerous ecosystem impacts. They can help maintain species and essential services such as pollination (Kremen & Ricketts, 2000). Corridors can also be sources of seed for revegetation and recruitment of the diversity of plant species.

If zones of connectivity are open to public access, open spaces can be important places for recreational hiking, biking, relaxing, etc. Also, rural and urban green zones as corridors can partly limit urban expansion. Buffer corridors on hillsides can limit hillside slumping, landslides, and erosion. Greenbelt corridors can also limit pollution, such as from busy highways and they can also be beneficial in agricultural systems. Hedgerows and other linear habitats can help limit soil loss due to wind and water erosion. Also, corridors can help retain snow pack in windy areas, increasing total water accumulation and storage.

Importance of planning and implementation of the ecological corridors concept

Habitat fragmentation and loss of natural habitat is one of the basic threats for many species. Idea of establishing ecological corridors, protection zones and

other links between protected areas is one of the main in enabling species movement from one habitat to another, and thus the protection of habitats and populations that inhabit them.

From the literature and from analyzing existing corridor projects, it is recommended to follow some general strategies for corridor implementation (Rapp, 1997):

- *Relationship in community*. Develop close working relationships among local citizen groups interested in land and water resources. They can be organized around activities such as farming, fishing, bird watching or watershed health.
- *Human resources*. Establish contact with resource agencies and other resources of expertise and possible funding early in the process. These organizations can publish and distribute produce leaflets and other educational materials valuable for community education, and promote the information on local fairs.
- *Diversity*. The richness of ideas and practices must be understood because it can be important for realization of a corridor project. Local and professional contacts will add to the diversity of objectives and strategies for restoration. Often, indigenous people have effective methods of working the land for the benefit of nature and community.
- *Education*. It is important to hold educational programs that show why conservation and protection are significant for local wildlife and human communities. Educational material providing justification for a corridor project can be distributed in public schools, local media and business organizations with large number of employees, etc.
- *Ecosystem approaches*. Try to maintain and restore the self-sustaining ecosystem processes in addition to native species, so that important functions can be maintained or recovered. This will require consideration of the larger landscape, including hydrological and geological processes, as well as local sources of pollutants, even when working on a small-scale project at a particular location.
- *Expectation of disturbance*. It is important to remember that natural and human-induced disturbances can affect the establishment, maintenance, and effectiveness of a corridor. Some actions can be taken to prevent losses, such as posting signs, building fencing, and securing treatments for extreme weather events, etc.

The number of corridor projects worldwide is unknown. In 2001, the International Union for the Conservation of Nature (IUCN) identified over 150

ecological network projects focused on conserving biodiversity with an emphasis on ecological interconnectivity, restoring degraded ecosystems, and conserving buffer zones (Bennett & Witt, 2001).

One of the most successful projects regarding ecological corridors and networks is Yellowstone to Yukon Conservation Initiative, a joint Canada-US non-profit organization aiming to preserve and maintain the wildlife and natural processes of the mountainous region from Yellowstone National Park to the Yukon Area. Approximately 10% of the Y2Y region is under some form of protected area status, and this region is one of the world's few remaining landscapes with the geographical and biological variety. Yellowstone to Yukon Conservation Strategy is primarily based on the conservation requirements of grizzly bears but with a secondary focus on bird and fish conservation needs. Using the conservation needs of grizzly bears as an indicator of biodiversity, it has been identified eight Priority Areas in the Y2Y region that function either as core wildlife habitat or as key corridors connecting those core areas (Anonim, n.d.).

Some authors were discussing about costs of maintaining such conceptions. Hunter and Gibbs (2009) emphasize the issue of cost effectiveness of corridor project, because of problems related with ownerships of areas crossed by corridor, expansion of diseases, introduction of exotic species, etc. So, for successful implementation of corridor projects it is important to evaluate all economical investments and costs of management activities.

Ecological Corridors and Ecological Network concept in Serbia

Since its first appearance in 1980s, the concept of the ecological network has become increasingly important in nature conservation. The basic premise of the concept is as follows: the habitat fragmentation can be mitigated by creating buffer zones to protect the survival of natural areas and connecting these core areas by stepping stones and corridors which allows species to colonize new areas and to migrate freely in search for food or a mate. This concept is becoming popular in Serbia especially in the last decade, and it is mainly recognized through creating of the ecological networks in Serbia. As a result of national efforts to solve fragmentation issues, many projects are realized or still in progress.

National ecological network. Realization of this network is in process and in the next period it will be documented with review and referral map with scale of 1:300.000. National ecological network includes 101 ecological important areas, as well as certain river flows which present ecological corridors of international

relevance (Mijović et al., 2012). This network includes 20,93% of territory of the Republic of Serbia.

Natura 2000. European ecological network of nature protection areas established under the Habitats Directive from 1992, on the initiative of European Union. The aim of the network is to assure the long-term survival of most valuable and threatened species and habitats. Natura 2000 network consists of Special areas of Conservation designated by member countries under the Habitats Directive, and also includes Special Protection Areas which they designate under the Birds Directive from 1979. Until now, it is included over 26.000 sites in Europe. The development of a list of the potential Natura 2000 sites in Serbia started under an EU funded Twining NATURA 2000 project. Identification of the sites will be followed by mapping of the Natura 2000 sites and preparation of the necessary database which Serbia will have to submit during the accession process. In Serbian Law on Nature Conservation (Official Gazette of the Republic of Serbia, nr. 36/2009 & 88/2010) it is defined that ecological network in Serbia will be established and become a part of European ecological network Natura 2000, so responsible institutions started a realization of Action plan for establishing the ecological network Natura 2000 in the Republic of Serbia for period 2011-2020 and Action plan for development of national ecological network in the Republic of Serbia for period of 2011-2015 (Mijović et al., 2012).

Emerald network. European ecological network of geographical areas and habitats of particular national and international relevance, in terms of biodiversity conservation. It is established in 1998 by Council of Europe as a part of activities covered by Convention on the Conservation of European Wildlife and Natural Habitats, known as Bern Convention. The Emerald Network consists of Areas of Special Conservation Interests for conservation on the territories of all member countries of Convention. Serbia is included from 2005, although it ratified the Convention in 2007. Council of Europe in 2005 started implementation of establishing of Emerald ecological network in South-Eastern Europe. With this project, species and habitats belonging to biogeographical regions are identified and important and endangered species are selected (SEE HNV, 2013). Potential Emerald sites are selected and database on distribution of certain habitat types and wildlife species is created in geographical information system. There are 61 areas in Serbia designated under the Emerald ecological network (Figure 4). Those areas are particularly important for protection and conservation of wildlife species and their habitats and they cover 11,54% of the territory of the Republic of Serbia (Mijović et al., 2012).

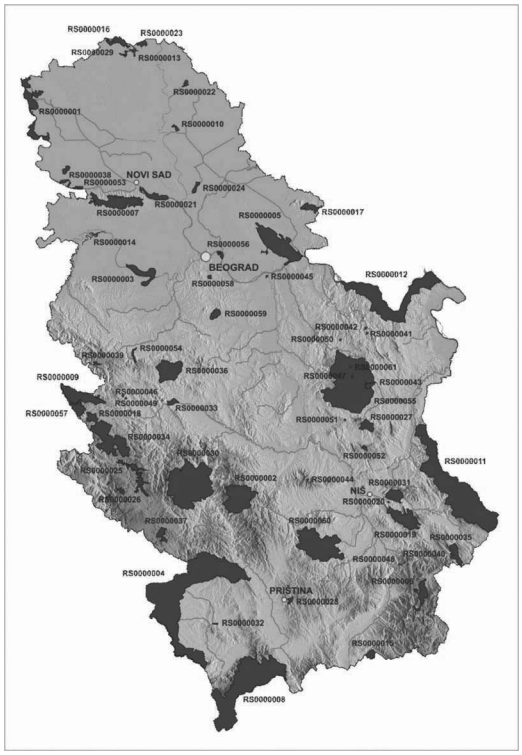

Figure 4. Emerald sites in Serbia (downloaded from http://www.natureprotection.org.rs/rs/ on 21/09/2012).

Pan-European ecological network of South Eastern Europe. One of the first initiatives for nature conservation on the international scale. The main goal is connection of different nature areas and ecological network of national and international relevance. This network aims to ensure that ecosystems, habitats, species and landscapes of European importance are conserved and protected. In the period from 2003-2006, the European centre for nature conservation was managing the project with the aim of developing the indicative map identifying core areas and corridors of the Pan-European ecological network for South-Eastern Europe, as well as promotion of the map as a tool for national and international policymaking in South-Eastern Europe (Mijović et al., 2012).

European green belt. Initiative was established by IUCN and the central goal is to create the backbone of an ecological network that runs from Barents to the Black Sea. This initiative includes some of the most important habitats for biodiversity and almost all distinct biogeographical region in Europe. It is established in 2004 with the aim of strengthening of crossborder cooperation in

nature conservation and regional sustainable development. The Green Belt spans 24 countries from the northern Europe, crossing central parts of Europe along the borders of Slovenia, Croatia and Hungary and continuing to the Black Sea, Aegean Sea, Ionian Sea and Adriatic Sea along the borders of Albania, FYR Macedonia, Romania, Serbia, Montenegro and Turkey. The route is rich in impressive and sensitive landscapes and it displays typical natural flora and fauna of the regions along its course. In Serbia, there are 11 areas included in Green Belt: Gornje Podunavlje area, Ludaško Jezero Lake, Subotička Peščara Sands, Selevenjske Pustare Wasteland, Pašnjaci Velike Droplje Pastures, Vršačke Planine Mountains, Deliblatska Peščara Sands, Đerdap Gorge, Stara Planina Mountain, Šar Planina Mountain and Prokletije Mountain.

Protection of biodiversity of the Sava River Basin Floodplains. The Sava river is recognized as one of the core European areas due to its biological and landscape diversity. The basin of the Sava river hosts the largest complex of alluvial floodplain wetlands in the Danube basin and the largest lowland forests. Central part of the Sava basin is true mosaic of natural floodplains and cultural landscapes formed by traditional land-use patterns typical for river valleys in the Central Europe in the past. In accordance with Habitats Directive and Bird Directive, it was established 51 habitats which present core areas for creating an ecological network. In Serbia, 9 areas are selected: Veliko Ratno Ostrvo Island, Crni Lug Forest, Bojčinska Šuma Forest – Živača, Obedska Bara Swamp, Trskovača, Orlača, Zasavica, Influence of Drina River and Bosutsko-Morovićke Šume Forest (Mijović et al., 2012).

Development of a Carpathian ecological network. Network is a part of the Pan-European ecological network with the aim on the protection and sustainable development of the Carpathians. This project was realized from 2006-2009, and it aimed to support the implementation of the Carpathian convention through the development and realization of a coherent transboundary ecological network as a part of sustainable development in the Carpathians. The project focused activities primarily in Romania, Ukraine and Serbia. The final outputs were the Carpathian biodiversity information system and an ecological network for the eastern part of the Carpathians (Mijović et al., 2012). In Serbia, with this project, 13 areas are selected: Šomrda, Liškovac, Miroč, Homoljske Planine Mountains, Beljanica, Mali Krš, Veliki Krš, Deli Jovan, Kučajske Planine Mountains, Rtanj, Tupižnica, Ozren and Devica.

Discussion

Fragmentation and loss of habitat is one of the main problems in actual nature conservation and they can have negative impacts on richness and diversity of wildlife. There are numerous ways to reduce this problem, but one of the most effective is facilitating connectivity within fragmented habitat and design and planning of ecological corridors. Corridor is usually linear space that improves the ability of organisms to migrate among fragments of their habitat. There are many types of corridors and they differ in size, morphology, purpose, etc. Corridors can serve as pathways to one species, but they can be barriers to another. There are many biological benefits from ecological corridors: they facilitate migrations (daily, seasonal, annual); they provide overall species persistence; connectivity of habitats; genetic interchange; avoidance of predation; healthy functioning of ecosystems. Also, they can limit urban expansion, landslide, erosion and pollution. Planning and implementation of ecological corridor projects are developed in North America, Australia and European Union. In Serbia, system of nature conservation recognizes ecological corridors as one of the basic elements of appropriate spatial and functional approaches in protection of autochthonous species and their habitats.

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References

Anonim (n.d.). *Yellostone to Yukon Conservation Initiative.* <http://y2y.net/>. Downloaded on 21 March 2013.

Anonim. (2009). *Law on Nature Conservation* (Official Gazette of the Republic of Serbia, nr. 36/2009 & 88/2010).

Anonim. (2010). *Statute on ecological network* (Official Gazette of the Republic of Serbia nr. 102/2010).

Beier, P. & Loe, S. (1992). A checklist for evaluating impacts to wildlife movement corridors. *Wildlife Society Bulletin, 20,* 434-440.

Bennett, A. F. (1999). *Linkages in the Landscape: The role of the corridors and connectivity in wildlife conservation*. Gland, Switzerland: World Conservation Union.

Bennett, G. & Witt, P. (2001). *The development and application of ecological networks: A review of proposals, plans and programmes.* IUCN Report B1142. Gland, Switzerland: World Conservation Union and AID Environment.

Brown, J. H. & Lomolino, M. V. (1998). *Biogeography*. 2nd Edition. Sunderland, MS, USA: Sinauer Associates.

Đurđić, S. (2010). Biogeographic foundations of creating protected areas networks. *Bulletin of the Serbian Geographical Society, 90 (4),* 147-158.

Fahrig, L. (2003). Effect of habitat fragmentation on biodiversity. *Annual Review of Ecology, Evolution and Systematics, 34,* 487-515.

Hanski, I. (1994). A practical model of metapopulation dynamics. *The Journal of Animal Ecology, 63 (1),* 151-162.

Henle, K., Lindenmayer, D. B., Margules, C. R., Saunders, D. A. & Wissel, C. (2004). Species survival in fragmented landscapes: Where are we now? *Biodiversity and Conservation 13 (1),* 1-8.

Hilty, J. A., Lidicker, W. Z. & Merenlender, A. M. (2006). *Corridor Ecology: The science and practice of linking landscapes for biodiversity conservation*. Washington, DC, USA: Island Press.

Hunter, M. L. Jr. & Gibbs, J. P. (2009). *Fundamentals of Conservation Biology*. Blackwell Publishing.

Kremen, C. & Ricketts, T. (2000). Global perspectives on pollination disruptions. *Conservation Biology, 14,* 1226-1228.

Levins, R. (1970). Extinction. In M. Gesternhaber (ed.): *Some mathematical problems in biology*. 77-107. Providence, Rhode Island: American Mathematical Society.

Mijović, A., Sekulić, N., Popović, S., Stavretović, N. & Radović, I. (2012). *Biodiverzitet Srbije: stanje i perspektive* (ed. A. Mijović). Beograd: Zavod za zaštitu prirode Srbije.

Perault, D. R. & Lomolino, M. V. (2000). Corridors and mammal community structure across a fragmented, old-growth forest landscape. *Ecological Monographs, 70,* 401-422.

Rapp, V. (1997). *What the river reveals: Understanding and restoring healthy watersheds.* Seattle: Mountaineers Books.

SEE HNV (2013). *South-East Europe HNV farming network*. <http://see.efncp.org/countries/serbia/general-info/> Downloaded on 18 March 2013.

Simpson, G. G. (1940). Mammals and land bridges. *Journal of the Washington Academy of Science, 30,* 137-163.

Soulé, M. E. & Gilpin, M. E. (1991). The theory of wildlife corridor capability. In: *Nature conservation 2: The role of corridors*, eds. D. A. Saunders & R. J. Hobbs, 3-8. Chipping Norton, New South Wales, Australia: Surrey Beatty & Sons.

Szabadoš, K., Bošnjak, T., Tucakov, M. & Kicošev, M. (2011). Značaj hidrološke mreže Vojvodine za očuvanje biološke raznovrsnosti. *Tematski zbornik radova Melioracije, 11*. Novi Sad: Departman za uređenje voda, Poljoprivredni fakultet, Univerzitet u Novom Sadu.

Udvardy, M. D. F. (1969). *Dynamic Zoogeography*. New York: Van Nostrand Reinhold.

USDA NRCS. (1999). *Conservation Corridor Planning at the Landscape Level: Managing for Wildlife Habitat*. United States Department of Agriculture, Natural Resources Conservation Service.

Walker, R. & Craighead, L. (1997). Analyzing wildlife movement corridors in Montana using GIS. ESRI User Conference Proceedings, California, <http://proceedings.esri.com/library/userconf/proc97/proc97/to150/pap116/p116.htm>. Downloaded on 18 March 2013.

http://balticgreenbelt.org.pl/

http://www.natureprotection.org.rs/rs/