Forest Ecology and Management 305 (2013) 1–10

Contents lists available at SciVerse ScienceDirect

Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco

Forest edges in managed riparian forests in the eastern part of the Czech Republic

Lubomír Šálek [a,*], Daniel Zahradník [a], Róbert Marušák [a], Lucie Jeřábková [b], Ján Merganič [a]

[a] Czech University of Life Sciences in Prague, Faculty of Forestry and Wood Sciences, Department of Forest Management, Kamýcká street 129, 16521 Prague 6-Suchdol, Czech Republic
[b] University of California, Department of Plant Sciences, One Shields av., Davis, 95616 CA, USA

ARTICLE INFO

Article history:
Received 16 February 2013
Received in revised form 2 May 2013
Accepted 6 May 2013
Available online 10 June 2013

Keywords:
Czech Republic
Edge effect
Extent
Forest edges
Riparian forest
Stand density

ABSTRACT

Forest edges usually possess unique composition and characteristics compared to interior forests. Knowledge of the width of the forest edges and their attributes are important in support of forest management as well as conservation decisions. However, in European deciduous forests, little information is available on the extent of this phenomenon. We have assessed the extent and magnitude of the forest edge effect on the stand structure and tree characteristics in managed riparian forests in the Czech Republic. We measured diameter at breast height (DBH), tree height, height of the first green branch, tree tilt and hollows in stems in 50 transects and subsequently calculated stand descriptors such as basal area, tree density, crown length ratio, and slenderness ratio. We also assessed natural regeneration and a shrub cover. The results support existence of a clear threshold between forest edge and forest interior conditions for all variables but proportion of trees with hollows and trees leaning to interior. The width of the forest influenced by proximity to forest edge was found to be between 4 and 18 m, with an average width of 8 m. Density of natural regeneration remained constant for the first 15 m and then declined farther into the interior. Shrub coverage declined steadily with the increasing distance from the forest edge. The distance from forest edge had significant negative effect on basal area and standing volume, while it had a positive effect on the proportion of straight trees, and slenderness ratio. We propose that an 8 m wide forest edge may be excluded from intensive forest management as it possesses inferior stand characteristics from a timber production point of view. At the same time, it shows some characteristics desirable for species conservation such as presence of large trees with capacity for snag recruitment and high shrub cover. Sufficient natural regeneration we observed further indicates capacity for persistence in the future. Forest edges in temperate riparian forests may thus be suitable candidate areas where conservation could be the primary objective of the forest management.

1. Introduction

Forest edges and edge effects have been widely studied in both Americas but in Europe there have only been few studies about forest edge effect (Harper et al., 2005). Forest edge is an abrupt transition between two relatively homogenous ecosystems, at least one of which is a forest (Matlack and Litvaitis, 1999). We can distinguish different types of edges in forests such as the boundary between harvested and standing sections and the boundary between forests and non-forest ecosystems (agricultural land, water bodies). In this paper we define a forest edge as an edge between forests and other open landscape patterns, mainly agricultural land. These edges, at least in Europe, are more stable than edges caused by forest harvest operations. According to many studies the structure of forest edges is different than the structure inside the forest (e.g. Chen et al., 1992; Oliver and Larson, 1996; Harper and MacDonald, 2001). However, limits of edge effect vary a lot depending on a type of forest and criteria for an edge effect. An edge effect is defined here as a change (e.g. in forest structure and growth) along the edge-to-interior gradient. An understanding of edge extent is necessary for determining the width of forest habitat that is different from interior forest. This information is important in guiding spatially explicit decisions about forest management and habitat conservation.

Generally, forest edges are evaluated from two points of view. In the first point of view, forest edges are appreciated because of higher biodiversity in comparison with forest interior (Perry et al., 2008; Šálek et al., 2010; Euskirchen et al., 2001), their static stability and resistance to wind-throws (Oliver and Larson, 1996), and capacity to retain more moisture from rain and fogs and to collect pollutants such as NH_4, NO_3 and SO_4 (Matlack and Litvaitis, 1999). From the other point of view, higher presence of forest edges corresponds with forest fragmentation. Fragmentation reduces the total area covered by forest interior, which may result in the reduction or extinction of some species and in addition,

* Corresponding author. Tel.: +420 728 624 826.
E-mail address: lubomir.salek@seznam.cz (L. Šálek).

0378-1127/$ - see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.foreco.2013.05.012

exposing the organisms that remain in the fragments to the condition of different surrounding ecosystems (Murcia, 1995; Cayuela et al., 2009).

Furthermore, it is necessary to distinguish between the effects on various forest ecosystem characteristics. While the edge effects on biodiversity may be spread from 100 m to the distance of 1 km along the edge-to-interior gradient (Bueno et al., 2012; Broadbent et al., 2008) the growth and tree quality response is significantly shorter and reaches the length of 5–50 m (Oosterhorn and Kappelle, 2000; Powell and Lindquist, 2011). Even for those effects that are apparent farther into the forest interior, the magnitude of the indicators has been found the biggest at the outer boundary from 0 to 20 m, such as number of understory plants (Euskirchen et al., 2001) number of climber species (Laurance et al., 2001), tree density (Cayuela et al., 2009; Russell et al., 2000; Harper and MacDonald, 2001; Oosterhorn and Kappelle, 2000; Palik and Murphy, 1990) and stem and crown shape (Oliver and Larson, 1996; Matlack and Litvaitis, 1999). The extent of the forest edge effect is among other factors modified by stability of the edges in terms of their boundaries and/or characteristics of the adjacent ecosystem (Burley et al., 2010) as well as the length of time over which the edge was able to develop, particularly for anthropogenic edges (Lopez et al., 2006).

Additionally, results of edge effects even on the same ecosystem or characteristic or processes have been inconsistent. Some studies reported higher rate of nest predation on or near the edge while other studies reported inconsistent or no significant edge effect on bird nest predation (Murcia, 1995). The abundance and richness of all forest dwelling bird guilds have then been found higher in forest edges compared to forest interior of temperate forests (Šálek et al., 2010; Yahner, 1988). Similar inconsistent results of edge effect have been reported for tree density. While some studies revealed that a tree density in the forest edge was lower than in the forest interior, mainly due to higher rate of tree mortality (Harper and MacDonald, 2001; Russell et al., 2000) other studies found the density in forest edges to be higher (Palik and Murphy, 1990; Oosterhorn and Kappelle, 2000).

Forest edges have often been promoted as beneficial to wildlife (Chen et al., 1992), however with many species and associated processes requiring suitable habitats in the forest interior, balance between the edge and interior environment has to be evaluated. Forest edges could play a specific role in protection of endangered organisms associated with forest ecosystems, particularly for saproxylic insects linked with old standing veteran trees (live, dying and dead) as forest edge could be areas where increased density of dead or decadent trees may be acceptable to the owners and manager. Large trees have gradually vanished from stands due to management decisions and loss of habitat lead to decline of the saproxylic insect populations (EU commission, 2009; Horák, 2012). EU established the Network Natura 2000 with emphasis of biodiversity maintenance where retention of veteran trees has been stated as important (EU commission, 2009). These trees can be continually maintained in forest edges. However, maintained European forests were not covered by studies reporting edge influences (Harper et al., 2005).

While forest edges can viewed as inferior areas from the timber management objective for their high proportion of trees with irregularly shaped stems, deeper crowns and wider branching, they could be good candidate areas with conservation as the primary objective of forest management for the same reasons.

Our aim was to assess the extent of the forest edge effect on complex structure characteristic in managed riparian forest, quantify habitat characteristics of interest to conservation such as number and proportion of quality trees, and to assess ability of regeneration and persistence of the edge areas in the landscape without management interventions.

While the size requirement and/or suitability of forest edges in particular ecosystems for individual target species has to be determined, we propose that excluding forest edges from intensive management and retaining them after harvest may increase the conservation value of the landscape while minimizing the negative effects on the economic value of forest harvest.

2. Materials and methods

2.1. Study area

We selected managed riparian forests to study the forest edge effects because tree species composition in riparian forests have not been changed dramatically and riparian forests maintain higher biodiversity in comparison with other temperate forest ecosystems (Mezera, 1956; UHUL, 1999). The study area is located in the eastern part of the Czech Republic, near the town Kromeriz (49°18′N and 17°24′E) along the river Morava (Fig. 1). The average altitude is 200 m above sea level. Climate is mild, the locality lies more or less on the border between oceanic and continental climatic influence. Average annual temperature is 8,6 °C and amount of annual precipitation is 599 mm (UHUL, 1999).

Riparian forest grows on alluvial soils, which were developed from riparian sediments; the soil type is fluvisol according to World Reference Base for Soil Resources (UHUL, 1999).

The area of forest in which stands were selected for this study has been stable for more than one century (UHUL, 1999). It means that edge effect could develop well in mature stands. Although the stands are designated as managed commercial forests they fulfill multiple functions apart from timber production, with intensive pheasant keeping, source for drinking water and last but not least recreation purposes being among the main ones. We chose stands from 72 to 130 years old, adjacent to meadows and arable land, as in these older stands the edge effect were likely more developed than in younger stands (Oliver and Larson, 1996).

Forest management in the area is oriented to the timber production of two main species – pedunculate oak (*Quercus robur* L.) and common ash (*Fraxinus excelsior* L.). The silvicultural system is clear-cut system with individual cutblocks having a maximum size of 2 ha. The length of rotation cycle varies from 80 to 140 years according to the dominant tree species in forest stands. Intensive tending treatments (pre-commercial and commercial thinning) are carried out during the stand development in order to produce a high quality timber. As the best quality timber is produced two-storied stands where either oak or ash are in overstory and shade tolerant tree species such as small-leaved lime (*Tilia cordata* Mill.), sycamore maple (*Acer pseudoplatanus* L.), common hornbeam (*Carpinus betulus* L.) and hedge maple (*Acer campestre* L.) occur in the lower story, the regeneration of shade tolerant tree species from advance regeneration is supported. The age of stands is counted from the year of artificial regeneration after clear cuts.

2.2. Plot design

We established 0.05 ha (10 $\times$ 50 m) rectangular sampling plots at each forest edge location. These plots were 10 m wide and extended 1 m outside of the forest and 49 m into the forest interior. At first we established the right corner of the rectangle as a point 1 m outside of the stand, in a perpendicular direction to a line connecting two randomly selected boundary trees. The positions of all trees were measured as their x and y coordinates from this point, representing the distance from the edge and width of the plot respectively. The trees were included in the plot if the x coordinate of their stem axis was smaller or equal to 50 m and y coordinate smaller or equal to 10 m.