Forest Ecology and Management 384 (2017) 1–5

Contents lists available at ScienceDirect

Forest Ecology and Management

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

Brushwood removal from ditch banks attracts breeding frogs in drained forests

Elin Soomets *, Asko Lõhmus, Riinu Rannap

Institute of Ecology and Earth Sciences, University of Tartu, Vanemuise 46, EE51014 Tartu, Estonia

ARTICLE INFO

Article history:
Received 14 June 2016
Received in revised form 6 October 2016
Accepted 9 October 2016

Keywords:
Afforestation
Ditch maintenance
Forested wetlands
Habitat management
Monitoring
Novel ecosystem

ABSTRACT

Forestry drainage has transformed extensive North-European wetlands to homogeneous forests with a dense network of open ditches. In such drained wetlands, small sun-exposed temporary water-bodies – a favoured breeding habitat for amphibians – are replaced by linear ditch corridors that become increasingly shaded by woody vegetation. We explored whether simple removal of woody vegetation from ditch corridors can increase the habitat quality for two frog species, *Rana arvalis* and *R. temporaria*, in a drained pine-wetland landscape in Estonia. Such practice is compatible with the forestry purposes of maintaining the ditches and access to the area. In a before–after–control–impact (BACI) experimental design, the mean shade above cleaned ditches decreased from 66% to 35% and appeared to be the main reason for a dramatic increase in frog breeding in the next spring. The change increased numbers of both species and was based on colonization of the ditches from the surrounding landscape. We suggest that keeping forest ditches exposed to the sun may mitigate the overall negative drainage impact on wetland species at least in the short term, and brown frogs could be used as focal species to guide these practices. In the longer term, however, such systems may not be viable without stable source populations in protected or restored wetland patches.

1. Introduction

Artificial drainage (ditching) is widely used to increase timber production in boreal and temperate forests in Europe, Asia and Northern America (Paavilainen and Päivänen, 1995). Such drained wetlands develop into novel ecosystems with no natural analogues – homogeneous forests with a dense network of open ditches (Lõhmus et al., 2015; Remm et al., 2013). The main change for freshwater organisms is that the natural diversity of sun-exposed water-bodies is largely replaced by shady linear ditch corridors, and the residual natural depressions become vulnerable to summer drying due to lowered groundwater levels (Suislepp et al., 2011).

Wetland qualities are critically important in the complex life cycles of amphibians – a taxonomic group that plays important roles in the functioning of forest ecosystems (e.g. Blaustein and Wake, 1995; DuRant and Hopkins, 2008; Wyman, 1998). In principle, several amphibian species can inhabit drained timber-production landscapes (Homyack et al., 2014; Remm et al., 2015), but the populations may not be viable in the long term without mitigation or restoration measures (Suislepp et al., 2011). Studies on such restoration of freshwater habitats in drained forests are lacking worldwide (Ilmonen et al., 2013), and the whole evidence base for conservation management of these novel landscapes is insufficient (Bernes et al., 2015; Lõhmus et al., 2015).

In this paper, we report on short-term response by breeding "brown frogs" (*Rana arvalis* and *Rana temporaria*) to brushwood removal from ditch banks in densely drained forest sites in Estonia. About 25% of all Estonian forest land is currently affected by artificial draining systems (Torim and Sults, 2005), and the 20th century transition from forest-wetland mosaics to densely stocked, ditched, and harvested forests is arguably one of the most fundamental recent landscape-changes of the country (Ilomets, 2005; Remm et al., 2015). Brown frogs prefer to breed in sun-exposed water bodies (Dibner et al., 2014; Hartel et al., 2010), and drainage has a double impact on them by transforming the water bodies and increasing the shade (Suislepp et al., 2011). Here, we focus on the role of shade. We test, using a before-after-control-impact (BACI) experiment, whether brushwood removal affects the numbers of breeding frogs and their tadpoles in ditches. Such practice is compatible with the production-forestry interests of maintaining the ditches and road access, and our manipulation addresses the general need for mitigation measures in permanently drained forests (Lõhmus et al., 2015). We also test whether water levels

* Corresponding author.
E-mail address: elin.soomets@ut.ee (E. Soomets).

http://dx.doi.org/10.1016/j.foreco.2016.10.023
0378-1127/

in ditches change after brushwood removal (as can happen due to reduced evapotranspiration; Lagergren et al., 2008; Sundqvist et al., 2014) and whether this has an additional impact on frogs. Our report supplements existing research on partial-cutting impacts on amphibians in forests (Bernes et al., 2015) with an explicit consideration of breeding-site (ditch) quality.

2. Material and methods

We used an ongoing restoration experiment in Soomaa lowland-forest and mire landscape in southwestern Estonia (58°20′N; 25°00′E; Fig. 1). This region has a humid temperate climate, with mean temperatures +17 °C in July and −5.5 °C in January, and ca. 750 mm annual precipitation. Most forests in this landscape developed after intensive draining in the 1960s on natural pine wetlands or open mires; they are currently dominated by Scots pine (*Pinus sylvestris*), with varying share of downy birch (*Betula pubescens*) and Norway spruce (*Picea abies*). Amphibians are represented by two "brown frogs" that frequently breed in drainage ditches – the moor frog (*Rana arvalis;* Annex IV species of the EU Habitats Directive) and the common frog (*R. temporaria*), and three less frequent species with scattered distributions. The latter include the common toad (*Bufo bufo*), edible or pool frog (*Pelophylax lessonae/esculentus*), and the smooth newt (*Lissotriton vulgaris*).

In 2014, we selected a total of 32 overgrown ditch sites (100-m sections at each site) in experimental areas where the mean density of the drainage network was 95 m ditches ha^{-1}. The sites were on histosol soils (including 21 sites on >100 cm peat), with heavy drainage-caused decomposition of the upper peat layer. Each site was a straight ca. 8–10 m wide corridor in the forest, comprising the ditch canal (3–4 m wide at the ground level) and partly decomposed and overgrown ditch spoil (the latter potentially usable as a logging road; Fig. 1A). Half of the sites in each area were subjected to manipulation and the others acted as controls. The minimum distance between two sites that received similar treatment was 250 m. The ditches were surrounded by 60–120 year-old pine-dominated forest, but two manipulated and two control sites had clearcuts at one side (5–6 years after the harvest). Historical aerial photos revealed that, in 1950, only nine sites had been forested and only one already had the ditch.

In half of the sites, mechanical removal of overgrowth from the ditch corridor was carried out between August and December 2014. In most cases, this was accompanied by a temporary logging road (possibly inducing some soil compaction) and additional trees fallen across ditches (Fig. 1B). In nine manipulated and four control sites, also the adjacent forest was thinned (up to 30% removal of canopy trees).

Ditch sections were sampled for amphibians and habitat structure by the same person (E.S.) in April and June 2014 (pre-manipulation) and 2015 (post-manipulation). These springs followed relatively snow-poor winters and (particularly 2015) had also below-average precipitation. As a result, frog breeding was confined to ditches, since natural pools were not available in the forests (E.S., unpublished data; see Suislepp et al., 2011 for a similar study system). In April each year, all amphibian spawn and individuals (males) present were counted by careful visual observations. The average water depth was measured and the shade (%) provided by woody canopies above the water table was visually estimated. The sites with amphibian breeding activity were re-visited and dip-netted for tadpoles in June (20 sweeps per 100 m). In 2015, we also measured water pH, using pH 4.0/pH 7.0 standard solution meter (Lutron PH-212), at four manipulated and six control sites.

We used a repeated-measures ANOVA approach for attributing between-year differences (repeated measure) to manipulation (categorical factor). In different analyses, the dependent variables were the number of spawn clumps of brown frogs in April; the

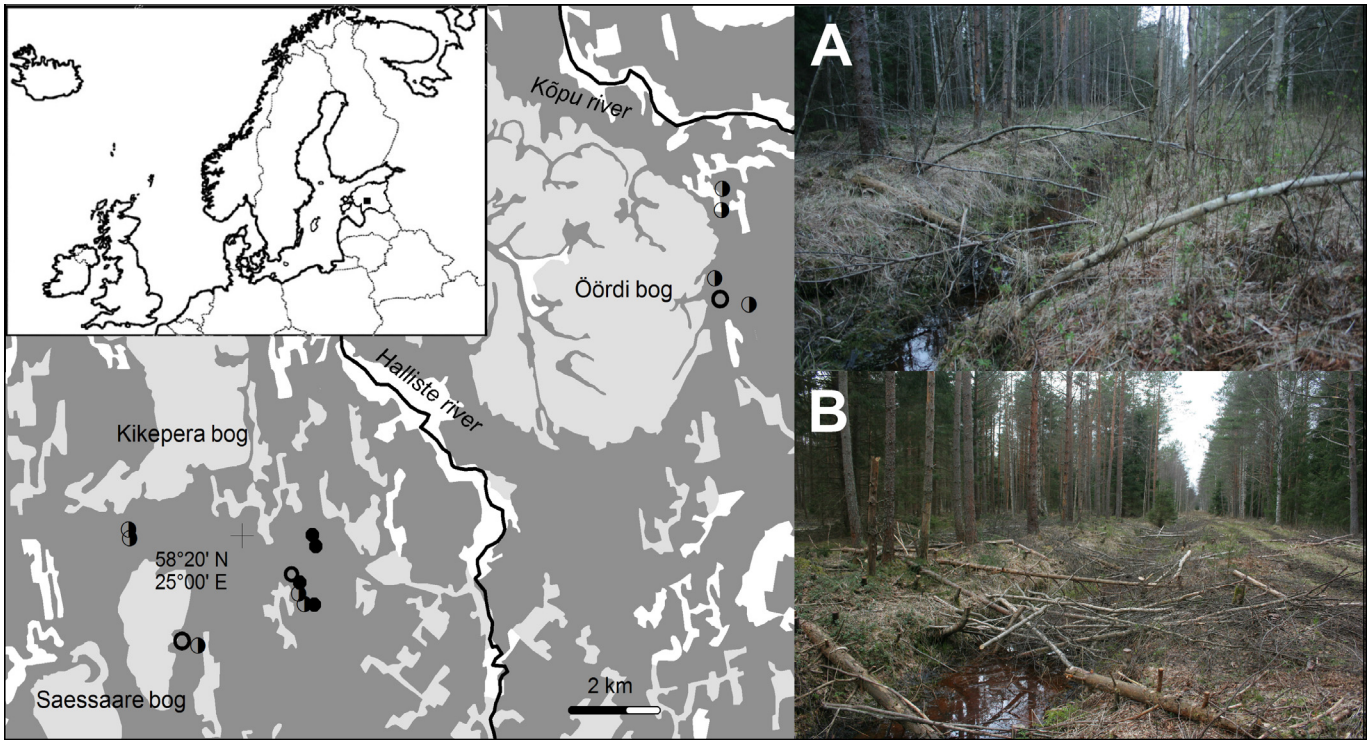

Fig. 1. The study area in Soomaa NP (left panel) and appearance of a typical experimental site before (A) and after (B) the canopy removal (right panel; photos taken in April). The symbols on the map are the 16 manipulated sites, distinguishing those with frogs breeding in both years (filled circle), not at all (empty circle) or appearing only after the manipulation (half-filled circle). The grey areas represent bogs (light) and forests (dark).