Forest Ecology and Management 408 (2018) 75–86

Contents lists available at ScienceDirect

Forest Ecology and Management

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

Stump extraction in the surrounding landscape: Predatory saproxylic beetles are more negatively affected than lower trophic levels

Åsa Ranlund, Jonas Victorsson*

Department of Ecology, Swedish University of Agricultural Sciences, Box 7044, SE-75007 Uppsala, Sweden

ARTICLE INFO

Keywords:
Bayesian hierarchical models
Deadwood
Habitat loss
Landscape
Forestry intensification
Saproxylic beetles
Stump extraction

ABSTRACT

To harvest more biofuel from forests, tree stumps are sometimes extracted after clearcutting. Species in different organism groups rely on deadwood, and biofuel extraction reduces their substrate. Our aim was to investigate the potential landscape effects of stump extraction, and compare the effects among trophic levels of deadwood-dependent (saproxylic) beetles. We sampled saproxylic beetle species in clearcut stumps using bark sieving. We did the study in 2013 in 49 clearcuts (1–4 years old) in three regions in central Sweden where stump extraction had been performed for six years prior to sampling. We selected landscape buffers with 500 m, 1000 m, and 2000 m radius with different intensities of stump extraction (0–100%). We show for the first time, based on empirical data, that increasing stump extraction can affect deadwood-dependent species at the landscape level. On average, obligate predators were more negatively affected than cambivores and facultative predators. The 34 studied saproxylic beetle species showed varied responses to stump extraction in the surrounding landscape, including stable (no response), negative, or positive responses. Positive responses could be due to a crowding effect, indicating a time-lagged response to habitat loss. Since stump extraction in the study area started just six years prior to sampling, time-lags in population-level responses could be expected. The age of the sampled clearcuts influenced the abundance of eleven species, but other local factors had little effect on abundance.

Our results suggest that if stump extraction is widely introduced, deadwood retention—planned for both spatial and temporal continuity—should be an integrated part of intensified forest management. We suggest monitoring the long-term effects of stump extraction.

1. Introduction

Human land use is considered one of the biggest threats to global species richness (Maxwell et al., 2016). Even where land use has a long history, intensified management can threaten vulnerable species. For example, with increasing demand for bioenergy as an alternative to fossil fuels, there has been increased extraction of logging residue (de Jong and Lönnberg, 2010; Walmsley and Godbold, 2010). Tree branches and tops are often removed after harvest, and newer practices sometimes include removal of tree stumps as well. In Swedish forests, extraction of branches and tops is performed on approximately 60% of the clearcut areas every year (Swedish Forest Agency, 2014). Stump extraction is a newer practice that is currently performed on only 1% of the clearcuts (Swedish Forest Agency, 2014). Although it has the potential to produce 5–10 terawatt hours (TWh) per year (von Hofsten, 2006), equivalent to 2.5–5% of the energy currently derived from fossil fuels (Anonymous, 2011), concern about its environmental impacts has restricted its implementation in Sweden. Many species depend on deadwood (saproxylic organisms), and might be adversely affected by such intensified forestry practices (Stokland et al., 2012). The available habitat for saproxylic beetles in Sweden is reduced by harvesting for bioenergy (Bouget et al., 2012; Felton et al., 2016). This could put more pressure on this organism group where over 500 species are red-listed in Sweden (De Jong et al., 2004). Although landscape-level effects of land-use intensification are often important (e.g., for pollinators in agricultural landscapes, Cariveau et al., 2013), and simulation studies support the relevance of considering a landscape perspective (e.g. Ranius and Roberge, 2011; Johansson et al., 2016), we still know little about the landscape effects of forestry intensification on saproxylic organisms (Ranius et al., 2017).

Stumps are an important substrate for species in several organism groups (Persson et al., 2013; Kataja-aho et al., 2016; Kubart et al., 2016; Svensson et al., 2016; Taylor and Victorsson, 2016); and notably, > 40% of the total landscape-wide population of some beetles is found in clearcut stumps (Jonsell and Schroeder, 2014). Tree stumps make up a large proportion of available deadwood in managed forest landscapes

* Corresponding author.
E-mail address: jonas.victorsson@slu.se (J. Victorsson).

http://dx.doi.org/10.1016/j.foreco.2017.10.030
Received 26 June 2017; Received in revised form 23 August 2017; Accepted 16 October 2017

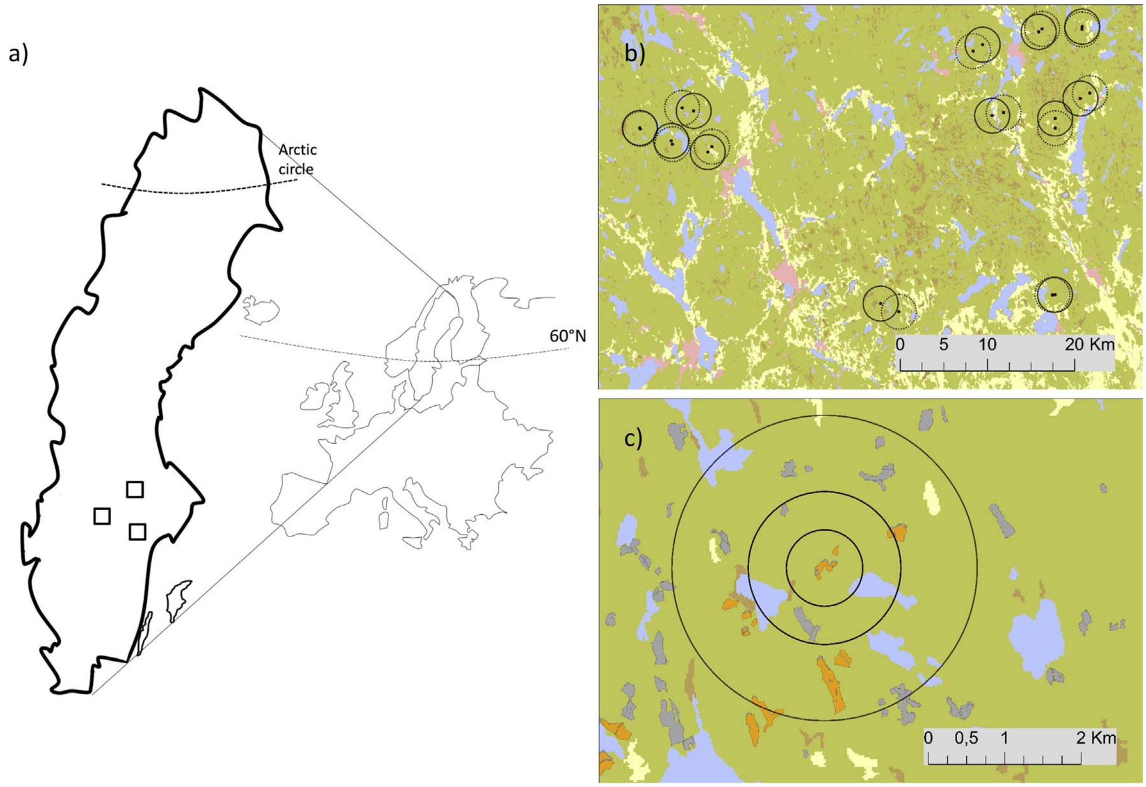

Fig. 1. The three study regions in central Sweden (a). In each region, stumps were sampled in focus clearcuts and landscape variables were estimated in buffers around those clearcuts (b). Landscape variables were estimated in buffer zones of 500 m, 1000 m, and 2000 m surrounding the focus clearcut (c). Clearcuts where stumps have been extracted are shown in orange, and clearcuts without stump extraction are shown in grey. Green is forested land, blue is lakes or wetlands, yellow is agricultural land, and pink is settlement. In panel b the 2000 m buffers are indicated, solid lines are buffers around stump extracted clearcuts and dashed lines are buffers around ordinary clearcuts.

(Svensson et al., 2016). In one particularly well-studied landscape in central Sweden, where all types of deadwood were inventoried, the bark area of clearcut stumps made up 38% of the total bark area of deadwood for the most common tree species, Norway spruce (*Picea abies*) (Jonsell and Schroeder, 2014). When stumps are extracted for biofuel, stump wood volume decreases by more than half (51–81%) (Eräjää et al., 2010; Rabinowitsch-Jokinen and Vanha-Majamaa, 2010; Victorsson and Jonsell, 2013a). With stump extraction, there could be considerable loss of habitat for deadwood-dependent species. Indeed, negative effects of stump extraction at the stand level have been detected in some saproxylic beetles and myriapods 1–3 years after clearcutting (Victorsson and Jonsell, 2013b; Taylor and Victorsson, 2016), and modelling predicts that some saproxylic beetle populations will decrease because of stump extraction (Johansson et al., 2016).

Intensified management and habitat loss do not affect all species equally. Species at higher trophic levels could be more vulnerable to habitat loss because they tend to have smaller population sizes than basal species (Henle et al., 2004; Morin, 2011) and small populations are more prone to local extinctions (e.g. Matthies et al., 2004; Henle et al., 2004). In the saproxylic beetle community cambivores feed directly on inner bark and outer sapwood. Cambivores require only a suitable dead tree, whereas predators and fungivores, species at higher trophic levels, also need the tree to be colonized by suitable prey or fungi (Jonsell et al., 2005; Weslien et al., 2011). This can make predators vulnerable to factors that affect their prey. Among saproxylic beetles, studies have indicated that predators and fungivores are more sensitive to local habitat loss than are cambivores (Ryall and Fahrig, 2005; Vanderwel et al., 2006), including effects driven by local stump extraction (Andersson et al., 2012; Victorsson and Jonsell, 2013b).

Our aim was to extend the previous work done at the stand level by investigating the landscape effects of stump extraction intensity on the abundance of individual saproxylic beetle species in stumps created at clearcutting. To reduce the influence of local habitat factors, we stratified sampling to only survey Norway spruce stumps, eliminating variation connected to different host-tree species and deadwood type (Abrahamsson and Lindbladh, 2006; Ulyshen and Hanula, 2009; Jonsell and Hansson, 2011; Ranius et al., 2015). We also chose a relatively narrow time-span, focusing on the early successional community in 1–4-year old clearcut stumps. We studied the landscape effects of stump extraction where the practice had been conducted within six years prior to sampling. We quantified the effect of stump extraction intensity in the landscape as the percentage of clearcuts (0–100%) where stump extraction had occurred. At the same time, we controlled for local factors such as clearcut age and local habitat amount. We hypothesized that higher trophic levels (i.e., predators and fungivores) would be more negatively affected by stump extraction intensity in the surrounding landscape than lower trophic levels (i.e., cambivores).

2. Material and methods

2.1. Study regions

The study was conducted in three regions in central Sweden: Lindesberg (59°25′0″N, 15°15′0″E), Finspång (58°42′33″N, 15°47′13″E), and Laxå (58°59′11″N, 14°37′9″E). The sizes of the study regions were: Lindesberg 2700 km^2, Finspång 330 km^2, Laxå 610 km^2. Almost all forested land in these regions is intensively managed with clearcutting and thinning. The dominant tree species are Norway spruce *Picea abies* (L.) Karst. and Scots pine *Pinus sylvestris* L.

2.2. Focal-patch study

The study was conducted as a focal-patch study (Brennan et al., 2002), where landscape effects are explored using local sampling of