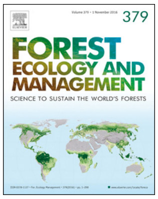
Forest Ecology and Management 432 (2019) 132–139

Contents lists available at ScienceDirect

Forest Ecology and Management

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



Inter-annual variation in species composition and richness after coppicing in a restored coppice-with-standards forest

Ilka Strubelt[a,b,*], Martin Diekmann[b], Detlef Griese[c], Dietmar Zacharias[a]

[a] *Applied and Ecological Botany, Faculty 5, University of Applied Sciences Bremen, Neustadtswall 30, 28199 Bremen, Germany*
[b] *Vegetation Ecology and Conservation Biology, Institute of Ecology, FB 2, University of Bremen, Leobener Str. 5, 28359 Bremen, Germany*
[c] *Dr. Detlef Griese, Gänseweide 5, 38542 Leiferde, Germany*

ARTICLE INFO

Keywords:
Coppice-with-standards
Coppicing
Galio-Carpinetum
Oak forest
Quercus robur
Species richness

ABSTRACT

Aims: Coppice-with-standards (CWS) management was one of the most important disturbances in Central European forests in the past. As our knowledge about the effects of coppicing on species richness and composition needs to be enhanced, we carried out vegetation studies in the currently largest CWS project in Germany. In this article we focus on two issues: 1. Coppicing induced changes and trends in species richness and composition from year to year and 2. Development of species richness and composition in 19 years of CWS restoration.

Location: Salzgitter Höhenzug mountains between Liebenburg and Goslar, Lower Saxony, Germany. Climate: subatlantic to subcontinental; soil: Limestone rendzina with low water storage capacity.

Methods: In 2013 we resurveyed the plant species composition of 12 permanent plots analysed every year from 1994 till 2002. The dates of coppicing were recorded for all of these plots, which enabled us to analyse the dynamics of species richness and composition after coppicing on a year to year basis. Differences in species richness and composition were analysed using ANOVA, H-test, DCA and GLMM.

Results: In 19 years of CWS restoration mean plot species richness increased significantly, mainly attributed to the increase in woody species, such as *Quercus robur* and *Sorbus torminalis*. The Ellenberg indicator value for nutrients decreased significantly, whereas the indicator value for light increased significantly. The typical dynamic after coppicing consists of a continuous increase in shrub layer coverage and an increase in herb layer coverage with a maximum in years 3 and 4 after coppicing. Total species richness as well as richness of open habitat and forest species and true forest species also showed an increase with its maximum in years 3 and 4 after coppicing.

Conclusions: Our results showed that the alternation of light and shaded phases had a positive impact on species richness, particularly on tree regeneration. Considering the trend of decreasing species richness level in Central European forests, CWS forests play a major role in the conservation of vascular plant species diversity. In contrast to other studies, the increase in species richness after coppicing did not result from an increase in weedy, nitrogen-demanding species. The so called “nitrogen time bomb” scenario (which other authors assumed to be happening after opening the canopy) did not occur in the studied area. The low water storage capacity of the limestone rendzina soil may be one reason, as there was not sufficient water and nitrogen for the more demanding species.

1. Introduction

Almost all European forests have been altered by management and are still being managed, therefore it is important for forest biodiversity conservation to understand the effects of these human-induced disturbances on biodiversity (e.g. Boch et al., 2013, Kaufmann et al., 2017,

---

Abbreviations: CWS, coppice-with-standards; OHFS, open habitat and forest species class 2.1 (Schmidt et al., 2011): species occurring more or less equally often in forests and open habitats; TFS, true forest species class 1.1 (Schmidt et al., 2011): species with their main occurrence in closed forests; EIV, Ellenberg indicator value; EIV F, Ellenberg indicator value for soil moisture; EIV L, Ellenberg indicator value for light; EIV N, Ellenberg indicator value for soil nutrients; EIV R, Ellenberg indicator value for soil reaction; YAC, year after coppicing

[*] Corresponding author at: Applied and Ecological Botany, Faculty 5, University of Applied Sciences Bremen, Neustadtswall 30, 28199 Bremen, Germany.

E-mail addresses: ilka.strubelt@hs-bremen.de (I. Strubelt), mdiekman@uni-bremen.de (M. Diekmann), detlef.griese@t-online.de (D. Griese), dietmar.zacharias@hs-bremen.de (D. Zacharias).

https://doi.org/10.1016/j.foreco.2018.09.014
Received 17 July 2018; Received in revised form 6 September 2018; Accepted 7 September 2018

Nomenclature

Garve (2004) for vascular plants

Paillet et al., 2010, Reier et al., 2005). Among the most important disturbances in Central European deciduous forests in the past were coppicing and coppice-with-standards (CWS) management, as these were the most widespread practiced forest management types from ca. the 13th century to the beginning of the 20th century (Ellenberg & Leuschner, 2010, Härdtle et al., 2004). The CWS management system consists of disturbances occurring on a regular basis and is therefore a good model for studying the effects of human-induced disturbances. The typical CWS forest consists of two important layers: The underwood (coppice layer) consisting of shrubs, young trees and stump regrowth used as firewood and the standards (solitary trees) used for feeding animals (acorns) and as timber (Ellenberg & Leuschner, 2010, Peterken, 1993). Coppicing is a rotation system based on harvesting the underwood in a particular area in one year, moving to the next area in the following year and coming back to the initial area after a certain time period of 7 (Szabó et al., 2015) to 40 years (Szabó, 2010). The standards are usually kept for longer rotation periods (Ellenberg & Leuschner, 2010). This regular human impact causes disturbances whose effects in terms of light can be compared with those of old fallen trees in virgin forests (Scherzinger, 1996). The alternation of light and shaded phases in the CWS forests provides a mosaic of different habitats, which is an important factor for biodiversity (Ellenberg & Leuschner, 2010; Lundholm, 2009; Shmida & Wilson, 1985; Strubelt et al., 2017). CWS forests are comparatively species-rich systems (Ellenberg & Leuschner, 2010; Kirby et al., 2017), where light-demanding and shade-tolerant plant species can co-exist (Hédl et al., 2017a; Vild et al., 2013). Usually oaks (*Quercus robur* and *Q. petraea*) and hornbeams (*Carpinus betulus*) were used for this management system, as oak trees were important for feeding livestock (acorns) and for timber harvesting and hornbeam trees show a better ability to regrow from stumps than beeches (*Fagus sylvatica*; which represent the potential natural vegetation in most of the Central European forests) (Ellenberg & Leuschner, 2010). From the beginning of the 20th century the forest management system changed from CWS to high forest management (Härdtle et al., 2004), which resulted in a strong decrease in plant species diversity (Becker et al., 2017; Hédl et al., 2010; Kopecký et al., 2013; Müllerová et al., 2015) and changes in species composition, with an increased proportion of true forest species (Becker et al., 2017) and a decline or even disappearance of light-demanding species (Hédl et al., 2010; Kopecký et al., 2013). Vild et al. (2013) showed that the restoration of the CWS management may reverse these processes and contribute to the survival of light-demanding species. However, to our knowledge, no research has so far explicitly addressed the effects of the event of coppicing on plant species richness and composition by analysing the year to year changes after coppicing in a restored CWS forest. As our knowledge about these processes, especially about the development of species richness and composition under the CWS management, needs to be enhanced (Hédl et al., 2017a), we carried out vegetation studies in the currently largest CWS project in Germany, a 171-ha large forest in the Forestry District Liebenburg in the northern part of the country. This forest had been managed as CWS over centuries up to ca. 1950 and has again been coppiced in a traditional way since 1986 (Geb et al., 2004, Meyer, 2010). We carried out detailed vegetation studies (focusing on vascular plant species) on permanent plots in this area every year from 1994 to 2002 and again in 2013. The dates of coppicing were recorded for all of these plots, which enabled us to analyse the dynamics of plant species richness and composition after coppicing on a year to year basis. To our knowledge, no other data set from CWS forests allows such analyses. In this article we focus on two issues: 1. Coppicing induced changes and trends in species richness and species composition from year to year and 2. Development of species richness and species composition in 19 years of CWS restoration. We specifically aim to answer the following questions: (1) How do species richness and composition change in the years after coppicing? (2) What are the dynamics of open habitat and forest species (OHFS) and true forest species (TFS) under CWS management? (3) How does the restoration of CWS management affect species richness as well as the EIV for F, L, N and R? (4) Which species show an increase or a decrease in 19 years of CWS restoration?

2. Materials and methods

2.1. Study area and forest management history

The studied area is situated within the 171-ha large CWS forest project Liebenburg, part of the Salzgitter Höhenzug mountains between Liebenburg and Goslar in North Germany (N-S 51°58′46.1″ – 51°58′04.2″N and W-E 10°25′08.5″ – 10°25′39.0″E, 220–290 m asl). The climate is subatlantic to subcontinental, with a mean annual temperature of 9.1 °C and a mean average annual precipitation of 712 mm (means for the years 1980–2010 in Liebenburg; www.dwd.de; accessed 18 Oct 2017). The soil is characterized by limestone rendzina with low water storage capacity. The site conditions as well as the vegetation type and structure are relatively homogeneous in this area. The mean pH($CaCl_2$)-value of the investigated plots is 5.5 (range: 4.6–6.2) (see also Appendix 1). The mean contents of some of the main soil nutrients per 100 g soil are: 1.3 (range 0.2–3.2) mg plant available phosphorus, 41.8 (range 28.5–61.1) mg magnesium, 957.3 (range 661.7–1207.3) mg calcium and 30.3 (range 21.6–39.6) mg potassium. The mean soil C/N ratio is 16.4 (range 14.1–20.1). All these variables were measured in

Table 1
Plots with their years of 1st and 2nd coppicing as well as the state of the plot in each year in terms of years after coppicing. NA: No investigation, n.c. = not yet coppiced.

Plot	Year of 1st coppicing	Year of 2nd coppicing	State of the plot in the investigated year in terms of YAC [yrs]									
			1994	1995	1996	1997	1998	1999	2000	2001	2002	2013
87/1	1986	2003	NA	10	11	12	13	14	15	16	17	11
87/2	1988	–	7	8	9	10	11	12	13	14	15	26
92/1	1991	2011	4	5	6	7	8	9	10	11	12	3
92/2	1992	2012	3	4	5	6	7	8	9	10	11	2
93/1	1993	2013	2	3	4	5	6	7	8	9	10	1
93/2	1993	2013	2	3	4	5	6	7	8	9	10	1
94/1	1994	–	1	2	3	4	5	6	7	8	9	20
94/2	1994	–	1	2	3	4	5	6	7	8	9	20
95/1	1994	–	1	2	3	4	5	6	7	8	9	20
95/2	2001	–	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	1	2	13
96/1	1996	–	n.c.	n.c.	1	2	3	4	5	6	7	18
96/2	2002	–	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	1	12