Forest Ecology and Management 382 (2016) 31–38

Contents lists available at ScienceDirect

Forest Ecology and Management

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

Frequent coppicing deteriorates the conservation status of black alder forests in the Po plain (northern Italy) ☆

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ARTICLE INFO

Article history:
Received 20 June 2016
Received in revised form 30 September 2016
Accepted 3 October 2016

Keywords:
Coppice
Floodplain forests
Forest management
Habitat Directive
Non-native species
Plant diversity
Understory

ABSTRACT

Alluvial forests with black alder are a priority conservation habitat in Europe. In the Po plain, black alder is traditionally managed by coppicing with frequent rotations. This study aims to ascertain whether such management is compatible with habitat conservation, by measuring the effect of time since coppicing on forest structure and plant species composition across different layers.

We compared the effects of three treatments, each thrice replicated: recent (10–20 years), medium (20–30 years) and old coppice (>40 years). In all nine stands we measured basal area, tree and regeneration density, mean tree diameter and height, dominance by alder, species richness, Shannon diversity, and the number of ruderal and non-native species. Significant differences in dendrometric variables, species richness, diversity, and percent cover by chorotype were assessed for treatment effects by two-way ANOVA.

Frequently coppiced stands had a lower basal area, mean tree size, and volume, a more simplified vertical structure, a lower cover of the herbaceous layer and higher bare soil cover due to harvesting disturbance, a significantly lower cover by typical woodland *Fraxinetalia* species, and a significantly higher frequency and cover of non-native species.

Our study showed that frequent coppicing worsened the conservation status of black alder forests in the study area, simplified stand structure, deteriorated species composition, and increased the spread of non-native and ruderal plant species. Such negative effects persisted even 20–30 years after cutting. We recommend amending the current legislation and introducing mandatory Implications Assessment procedures everywhere alder forests are susceptible to be impacted in a similarly negative way.

1. Introduction

Black alder (*Alnus glutinosa* (L.) Gaertn.) is a tree species of riparian and water-logged habitats that is naturally widespread from mid-Scandinavia to southern Europe (Kajba and Gracan, 2003). It forms pure stands on periodically submerged sites, while it mixes with ash (*Fraxinus excelsior* L.), maples (*Acer pseudoplatanus* L. and *Acer platanoides* L.) and oaks (mostly *Quercus robur* L.) on riverside and plateau sites (Dethioux, 1974), where its intolerance to shading and lower groundwater tables reduce its ability to compete (Claessens et al., 2010).

Black alder grows between sea level and 1300 on the Alps (Shaw et al., 2014). It is largely indifferent to soil parent material, but it requires precipitation above 510 mm per year and high water saturation (McVean, 1953), and a high degree of atmospheric humidity throughout its reproductive cycle. When the water-table sinks below the surface during summer, tree growth increases but seedlings may suffer from drought (McVean, 1953). The tree is able to fix atmospheric nitrogen in symbiotic root nodules (Bond et al., 1954), and its litter increases nitrogen and phosphorous content of the soil (Moiroud, 1991; Giardina et al., 1995). The species has a maximum lifespan of 100–160 years (Claessens et al., 2010). It reaches sexual maturity at age 3–30, when it starts producing seeds with mast pulses every 3–4 years (Dethioux, 1974). Seeds are dispersed by water or wind (up to 150 m: McVean, 1955, but usually within 30 m: Funk, 1990). However, regeneration occurs

☆ GV wrote the paper and carried out statistical analyses, FM and GC carried out field sampling and forest structure analyses, MFe designed and coordinated the research and carried out imagery analyses, MFr carried out soil sampling and analyses, RM provided input for study design, interpretation and discussions, and ML carried out phytosociological analyses.

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http://dx.doi.org/10.1016/j.foreco.2016.10.009
0378-1127/

mostly from vegetative reproduction, e.g. in linear flood populations (Koop, 1987; Deiller et al., 2003). Regeneration from seed is usually scattered and it occurs under favourable establishment conditions, e.g., on low-lying alluvial land or on former meadows (Douda et al., 2009). Seedlings require a higher light intensity than those of larger-seeded trees (McVean, 1956); it was found that natural regeneration of black alder is not possible under the canopy of a mature stand (Tapper, 1993), except in openings >0.1 ha (Claessens et al., 2010). The regeneration of black alder also depends on the frequency and intensity of disturbance (e.g. browsers, floods, or forest harvesting) (Pokorný et al., 2000; Wolf et al., 2004), and on the abundance of herbs that may compete with the seedlings (McVean, 1956).

Due to their specific hydrological regime and rare occurrence, black alder forests and carrs are considered an endangered forest community in Europe (Ellenberg, 1996). Alluvial forests with black alder and ash are a priority habitat of Community interest listed in the Annex I of the Habitats Directive 92/43/EEC as 91E0* – Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion*, *Alnion incanae*, *Salicion albae*). These forests are highly important for the conservation of a great number of typical woodland and floodplain plant species (Claessens, 2003), particularly when interspersed in an agricultural matrix. Despite being often small and fragmented (Schnitzler, 1994), black alder forests are often characterized by a high richness in herbaceous species (Brown et al., 1997). Beyond plant diversity, black alder forests support other ecosystem services as well, such as water filtration and purification in waterlogged soils (Peterjohn and Correll, 1984), flood control and riverbank stabilization (Piégay et al., 2003).

Currently, these forests represent less than 1% of the forest cover in most European countries (Claessens et al., 2010) due to both land use changes such as conversion to non-native tree plantations or agricultural land, or to environmental changes related to human activities, e.g. land draining, impact of industrial areas, negative selection in favor of more valuable timber species such as oak and ash, and the introduction of non-native species (EEA, 2012). For these reasons, the conservation status of 91E0* habitat is currently "unfavourable inadequate" or "unfavourable bad" (Kremer et al., 2015).

In the Po plain, black alder is traditionally managed by coppicing, with rotations of 10–30 years due to the fact that the potential for vegetative regeneration from stumps declines at 60–80 years of age (Kapustinskaite, 1960). Private ownership usually prevails in floodplain forests, with the consequence of creating a mosaic of small but intense and frequent cuttings, which can deteriorate habitat conservation and spatial continuity. Moreover, floodplain forests are highly vulnerable to plant invasions due to the frequent and intense natural disturbances, to their linear nature which facilitates long-distance species dispersal, and to intensive human pressure (Richardson et al., 2007). In this perspective, the question arises whether such management is compatible with habitat conservation.

This study aims to ascertain the effect of time since coppicing on the conservation status of black alder stands, as measured by (a) forest composition, structure, and biomass, and (b) species composition and naturalness of the herbaceous layer, e.g., the relative frequency of ruderal and non-native herbaceous species.

2. Study area

The study was conducted in the Natura 2000 site "IT1110021 – Laghi di Ivrea" (Fig. 1), a 1600-ha Site of Community Importance (SCI) at the center of the 500-km^2 Ivrea Morainic Amphitheater (IMA). Mean annual temperature and annual precipitation are 12.5 °C and 1002 mm, respectively (years 1921–2000) (Andreone et al., 2001). The bedrock is a juxtapositions of three metamorphic units (eclogitic micaschists, basic granulites and vulcanites) as a result of uplift and underplating during the Tertiary Alpine orogenesis (Johnson, 1973). The Morainic Amphitheater was constructed between the Pleistocene and the Last Glacial Maximum (Carraro et al., 1975). Thereafter, small lakes formed in the gaps between secondary moraines, but most later evolved into peat bogs or were artificially drained. Such low-elevation sites are characterized today by Endoaquepts or Haplosaprists soils (Piazzi et al., 2007). The latter is predominant in peat and raised bogs, where the sapric organic material has an extremely slow hydraulic conductivity and C/N ratios may be as high as 45.

The site hosts 11 habitat types of the EU Habitats Directive (1992/43/EEC Annex I), among which the priority habitat 91E0* covers 59 ha. A total of 32 plant and animal species of the EU Nature Directives (1992/43/EEC and 2009/147/EC Annex II) (Natura 2000 Network Wiewer, 2016). Anthropic pressure has caused the number of plant species to decline from 179 to 160 species between 1950 and 2005; at least 12 non-native plant species were reported in the area so far (Minuzzo et al., 2005; Lonati et al., 2014).

Forests are mostly owned by small private owners. Between January 2012 and June 2015, 40 silvicultural treatments were authorized across 8 ha of 91E0* forests inside the site; 10% of this area was treated by thinning, 30% by coppicing, and 60% by contemporary cutting of the coppice and high forest layers (Regione Piemonte, 2016a).

3. Methods

We designed the study as a chronosequence of stands coppiced in three different times: recent (10–20 years, TR1), medium (20–30 years, TR2) and old coppicing (>40 years, TR0). To do so, we preliminarily assigned one of such treatments to all forest stands classified as 91E0* habitats (according to Andreone et al., 2001) within the study area, based on the analysis of repeated aerial images (years 1954, 1975, 1979, 1994–1996, 1998–1999, 2007, 2009). The images were orthorectified and georeferenced, then visually classified into forested/nonforested categories, and differentiated to obtain age ranges for each forest stand. Age classes were subsequently confirmed by field surveys and exploratory increment core sampling. Only stands belonging to the association *Carici remotae-Fraxinetum* Koch ex Faber 1926 (alliance *Alnion incanae* Pawłowski in Pawłowski and Wallisch 1928) and already existing in year 1954 were considered for further analysis, i.e., waterlogged stands of the alliance *Alnion glutinosae* Malcuit 1929 and secondary stands on former non-forested land were filtered out.

Following superposition to cadastral stand maps, we identified three independent study areas where all three elements of the chronosequence could be found in stands less than 100 m apart from one another, in order to minimize site differences between treatments and counter pseudoreplication. The only three areas where this condition was met in all the SCI are indicated in Fig. 1. A total of nine stands (i.e., 3 study areas × 3 treatments) were selected for analysis; stands were at a constant elevation (about 240 m a.s.l.) and had a mean size of 1120 m^2.

In spring 2015, in each stand we randomly established a circular sampling plot (radius = 10 m) where we recorded species, frequency, diameter at breast heigh (dbh), origin (seed or sucker) and height of all adult trees with dbh $\geqslant$ 7.5 cm. We also recorded species, frequency, origin, and height of all juvenile trees (dbh < 7.5 cm) in a concentric 6-m radius circular plot. From plot data we computed common descriptors of stand structure (species composition, number of trees per hectare, basal area, quadratic mean diameter, average and top height, percent trees originated