

The effect of gap size and shape on understory and regeneration in an oak-hornbeam forests managed by continuous cover forestry

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Forest biodiversity is primarily threatened by the conventional rotation forestry system. The fine-scale interventions of continuous cover forestry, such as gap-cutting, could serve as a valuable tool to protect forest habitats and enhance structural heterogeneity of the stand. However, it is unclear which gap sizes and shapes can trigger the natural regeneration while simultaneously maintaining or improving the near-natural character of the forest understory. This issue is particularly relevant for light-demanding tree species such as sessile oak (*Quercus petraea*). In this case, optimal abiotic conditions may also have an indirect negative effect by enhancing the competitive pressure.

In the Pilis Gap Experiment, we examined the five-year effects of four gap types, comparing two gap sizes (150 and 300 m²) and shapes (circular and elongated), on light conditions, understory vegetation and oak regeneration in an oak–hornbeam forest. The investigated understory variables included species richness, total cover, cover of different functional groups and species composition, while for the regeneration the survival, growth and abundance of sessile oak and the abundance of the main competing woody species were studied.

Our results indicate an increase in light in all gap types. However, light decreased over the years in large circular gaps, while remaining more stable in other gap types. Species richness experienced a temporary increase in large circular gaps, whereas total cover increased in all gap types. Understory height and shrub cover also increased in large circular gaps. Annual and perennial forb cover remained unchanged in all studied gap types, although graminoid cover showed a transient growth in large elongated gaps. Small gaps had the highest cover of woody regeneration, whereas bramble (*Rubus fruticosus* agg.) cover increased in large circular gaps. Species composition changed most in large circular gaps, and least in small elongated ones. Tended oak saplings showed the greatest height increment in large circular gaps, but without tending they were outcompeted in this gap type by hornbeam (*Carpinus betulus*) and bramble. When competition was also considered, small gaps proved to be the most favourable treatments for oak regeneration.

Vegetation changes have been most prominent in large circular gaps. While these gaps are favourable from a conservation aspect as they enhance the structural diversity of the stand, the dense cover of bramble and woody competitors hinders the effective sessile oak regeneration. Smaller gaps slightly increase the understory heterogeneity. These gap types also ensure ample light to initiate regeneration while prevent the expansion of competitors. However, in a later phase of the regeneration process, the extension of these gaps is necessary. If oak is regenerated in larger gaps, competition could be mitigated by using an elongated shape. In all cases, control of hornbeam is necessary, but its extent is lower in small and elongated gaps. The experiment proves that the regeneration of the light-demanding oak species can be successfully initiated by closer-to-nature continuous cover forestry system.

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