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Knowledge gaps about mixed forests: What do European forest managers want to know and what answers can science provide?

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ABSTRACT

Research into mixed-forests has increased substantially in the last decades but the extent to which the new knowledge generated meets practitioners' concerns and is adequately transmitted to them is unknown. Here we provide the current state of knowledge and future research directions with regards to 10 questions about mixed-forest functioning and management identified and selected by a range of European forest managers during an extensive participatory process. The set of 10 questions were the highest ranked questions from an online prioritization exercise involving 168 managers from 22 different European countries. In general, the topics of major concern for forest managers coincided with the ones that are at the heart of most research projects. They covered important issues related to the management of mixed forests and the role of mixtures for the stability of

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forests faced with environmental changes and the provision of ecosystem services to society. Our analysis showed that the current scientific knowledge about these questions was rather variable and particularly low for those related to the management of mixed forests over time and the associated costs. We also found that whereas most research projects have sought to evaluate whether mixed forests are more stable or provide more goods and services than monocultures, there is still little information on the underlying mechanisms and trade-offs behind these effects. Similarly, we identified a lack of knowledge on the spatio-temporal scales at which the effects of mixtures on the resistance and adaptability to environmental changes are operating. Our analysis may help researchers to identify what knowledge needs to be better transferred and to better design future research initiatives meeting practitioner's concerns.

1. Introduction

In recent years, the study of mixed forests has been the focus of increasing research efforts, in particular the consequences of admixing tree species for the productivity and stability of forest systems. This has generated a substantial amount of new knowledge (e.g. Pretzsch et al., 2013; Vilà et al., 2013; Morin et al., 2014; Tobner et al., 2016; Liang et al., 2016; van der Plas et al., 2016; among others), and the consolidation of important scientific initiatives and networks (Baeten et al., 2013; Bravo-Oviedo et al., 2014; Verheyen et al., 2016). From the research perspective, the recent advances in the understanding of mixed forests functioning are of unquestionable value, but the extent to which this information is responding to practitioners' concerns remains unknown.

We addressed this issue via a collaborative work in the context of the EuMIXFOR research network (Bravo-Oviedo et al., 2014) in which researchers from 30 different European countries participated. The study was divided into three steps. First, we conducted a Pan-European survey with the objective of identifying key questions related to mixtures that, from the perspective of forest managers, still require further research attention. Second, we ranked these questions by relevance according to the views of an independent set of European practitioners obtained via an online prioritization exercise. Finally, we evaluated current scientific knowledge for the highest ranked questions and we identified future research challenges in relation to them. The ultimate aim of our work was to reduce the commonly reported gap between knowledge generated from research and that required by forest managers (see Petrokofsky et al., 2010). In that respect, we expect our analysis will provide both (*i*) information to the research community on the priority knowledge needs of forest practitioners and (*ii*) brief reviews of the current state of knowledge regarding the topics of their concern. Finally, we expect that the identification of research challenges (based on the questions received from the practitioners) may help researchers to contextualise and design future research initiatives and may also facilitate the translation of new knowledge into practical outcomes.

2. Collection and prioritization of research questions by forest managers

2.1. Collection of questions

Each representative of the individual European countries that participated in the *EUMIXFOR* network contacted forest managers from that country who had expertise in the management of mixed-forests in either public or private ownership. We asked the managers to provide a list of the 5–10 key questions about mixtures for which they would like more information from the research community (preferably in the form of an interrogative sentence). Fifty-three forest managers from 15 countries responded to this request providing 289 questions (Fig. 1). The set of questions from each country was added sequentially to the pool of questions. The sets of questions identified by the last countries added to the list did not raise additional topics, suggesting that the main questions had already been covered and that adding new

Fig. 1. Schematic representation of the participatory process conducted with European forest managers for the selection of the 10 questions used to structure the review. The countries colored in green corresponded to the ones that contributed to step 1 (above) and step 3 (below).