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SHORT COMMUNICATION

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AHP for indicators of sustainable forestry under Mediterranean conditions

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Abstract

Aim of study: To verify and prioritise a set of sustainable forestry indicators using the Analytic Hierarchy Process (AHP).

Area of study: Participants were Spanish; indicators were meant to be applied in forest management units (FMUs) under Mediterranean conditions.

Material and methods: An AHP questionnaire was developed and sent to experts.

Main results: the set of indicators aimed to be comprehensive. Indicators were ranked and the ranking allows ascertaining what aspects are more relevant in relation to Mediterranean sustainable forestry. Issues like regeneration or habitats conservation got high values, whereas others like hunting activity were not seen as important by most experts.

Research highlights:

- Sustainable forest management (SFM) considerations for Mediterranean forests.
- Indicators adapt to ecosystem services.

Additional keywords: sustainability; monitoring; multiple criteria analysis.

Abbreviations used: AHP (Analytic Hierarchy Process); C&I (criteria and indicators); FMU (forest management unit); MCA (multiple criteria analysis); SFM (sustainable forest management)

Authors´ contributions Design, acquisition, analysis and interpretation of data and writing the paper. PVD. Critical revision of the manuscript: MVP. Revision and supervising of the work: FG.

Supplementary material (Tables S1 and S2) accompanies the paper on FS's website

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Introduction

Sustainable forest management (SFM) considers the social and environmental implications of forestry. Criteria and indicators (C&I) spread an understanding of the concept (Wijewardana, 2008), whose principles adapt to local circumstances (Castañeda, 2000; Barbati *et al*., 2007). The consideration of local conditions becomes especially relevant under Mediterranean conditions (Osem *et al*., 2008).

Valls-Donderis *et al*. (2015) identified C&I adapted to ecosystem services of Mediterranean forests and applicable at the forest management unit (FMU) scale. Those C&I are verified with stakeholders, however, their indicators are too technical for not professionals and these are arranged into aspects (general issues covered by a criterion).

Multiple criteria analysis techniques (MCA) help making choices when several criteria apply. Mendoza & Prabhu (2000) conclude that MCA methods are useful to prioritise and evaluate C&I, and that, for indicators, pairwise comparison methods, like the analytic hierarchy process (AHP), are more accurate. The aim of this research was to verify the indicators from Valls-Donderis *et al*. (2015) with experts using AHP.

Material and methods

The set of indicators identified by Valls-Donderis *et al*. (2015) consists of 133 indicators. Even though only the ones of the same criterion were meant to be compared, it still meant many indicator pairs to value.

To shorten the AHP questionnaire, the method was adapted: one indicator was compared against the others of the same criterion. Results should not have differed from the pure method: given A-B-C, if a respondent said that A was two times more important than B and A was five times C, if that respondent was consistent, she/he would have said B was three times C. Although Saaty (1980, 2006) states that consistency rarely happens, it was assumed in this study. Further considerations on the limitations and advantages of this simplified application of the AHP method are provided in the results and discussion section.

Saaty (1980, 2006) establishes that more than nine items cannot be compared. Most criteria had more indicators; some were deleted or joined and 103 indicators were finally presented to experts. The indicator of each criterion to be compared against the others were selected at random since researchers did not show special preference for any of the indicators (the indicators evaluated, and the criteria they belong to, are in Table S1 [suppl]).

The questionnaire was made of 15 questions (one for every criterion). In each question, n-1 pairs of indicators were shown (being "n" the number of indicators contained within the criterion). Next to each pair of indicators Saaty's valuation scale (Saaty, 1980, 2006) was provided as shown at the end of Table S1 [suppl].

Potential respondents were selected by means of purposive sampling. As described by Bernard (2000), the method consisted of deciding the profile of the individuals that would suit the study and going out to find them. A selection of 343 experts from the groups considered suitable (groups are referred in the results section) whose contact details were available in the internet, or by means of colleagues, were approached via e-mail.

Respondents could also make comments on the indicators or their valuations. Answers were aggregated according to the AHP process (quantitative analysis) described in Saaty (1980, 2006). Comments were put together (qualitative analysis); these comments served to select and rephrase indicators.

Results and discussion

A group of 44 experts completed the questionnaire: from central and local governments (8), universities (11), research centres (10), private and public enterprises (12), freelance (4), forest owners (9) and forestry associations (1). Concerning comments, 14 respondents made some.

A short version of the indicators appears in Figs. 1, 2 and 3, which show the weights of the indicators (see Table S1 [suppl] to check the whole version). Unlike most criteria, for two of them indicators got similar weights: "diversified exploitation of forests" (Fig. 1) and "education" (Fig. 2).

Some indicators were deleted as a result of the low weight obtained in the quantitative analysis. Some others were also deleted or arranged taking into account the comments from respondents. Table S2 [suppl] explains changes applied. The final set was made of 94 indicators.

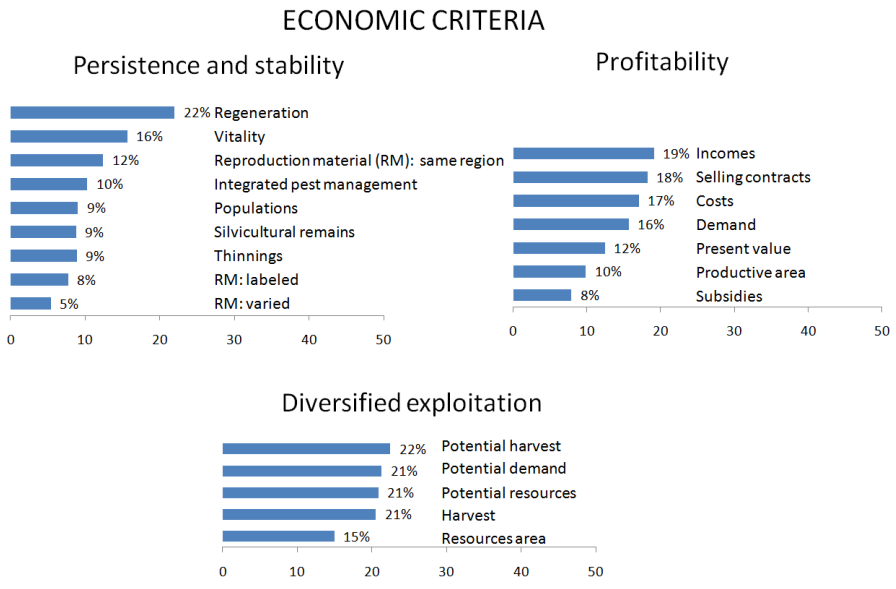

Figure 1. Weights of the indicators of the economic criteria

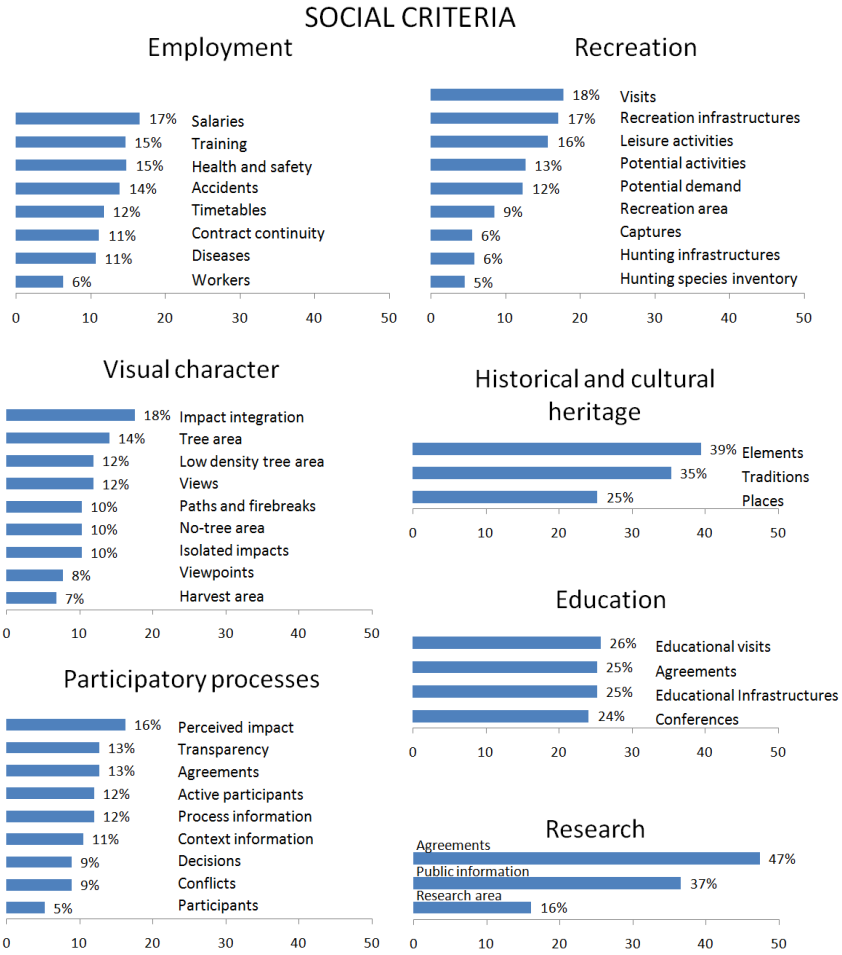

Figure 2. Weights of the indicators of the social criteria

It is argued that forestry creates job opportunities (AENOR, 2007; GTC-FSC, 2012). However, *workers* (criterion "employment") got the lowest weight (Fig. 2). This indicator becomes relevant when planning at national or regional level. But, each FMU can afford a maximum number of workers.

Hunting indicators ("recreation") had low values (Fig. 2): *captures, hunting infrastructures, hunting species inventory.* Either respondents considered hunting an economic activity or they were against it; this was much unexpected since this activity provides incomes and, given the low productivity of Mediterranean forests, it would be relevant as a SFM issue (Maroto *et al*., 2013).

It was surprising that the indicator *participants* ("participatory processes") got a low weight (Fig. 2). Probably, experts understood it in terms of quantity and not representation of the different stakeholders involved and affected people.

Fire causes ("forest fires") was valued high (Fig. 3) since the origin of 15% of Spanish fires remains unknown (MARM, 2008). Surprisingly, *bush density* was valued low considering that fires spread faster because of bushes.

More organic carbon is kept in soils than in vegetation (Bravo, 2007). Nevertheless, respondents valued soil carbon storage indicators low ("carbon storage"): *dry soils area, altered soils area and silviculture limitations* (Fig. 3). Based on experts' comments, forestry acts on vegetation and a proper management should not have a big impact on soil structure and content.

Regarding the method, many weaknesses were incurred from simplifying the AHP methodology. Most respondents are never consistent (Saaty, 2006). The proper AHP method allows rethinking someone's opinion on the elements evaluated; therefore, a first respondent's opinion on an indicator may change when comparing it with another indicator; this change of mind did not happen after the simplification. However, Macharis *et al*. (2004) say that the 9-point scale of the AHP method is a disadvantage because a respondent could think that alternative A was five times more relevant than alternative B and B seven

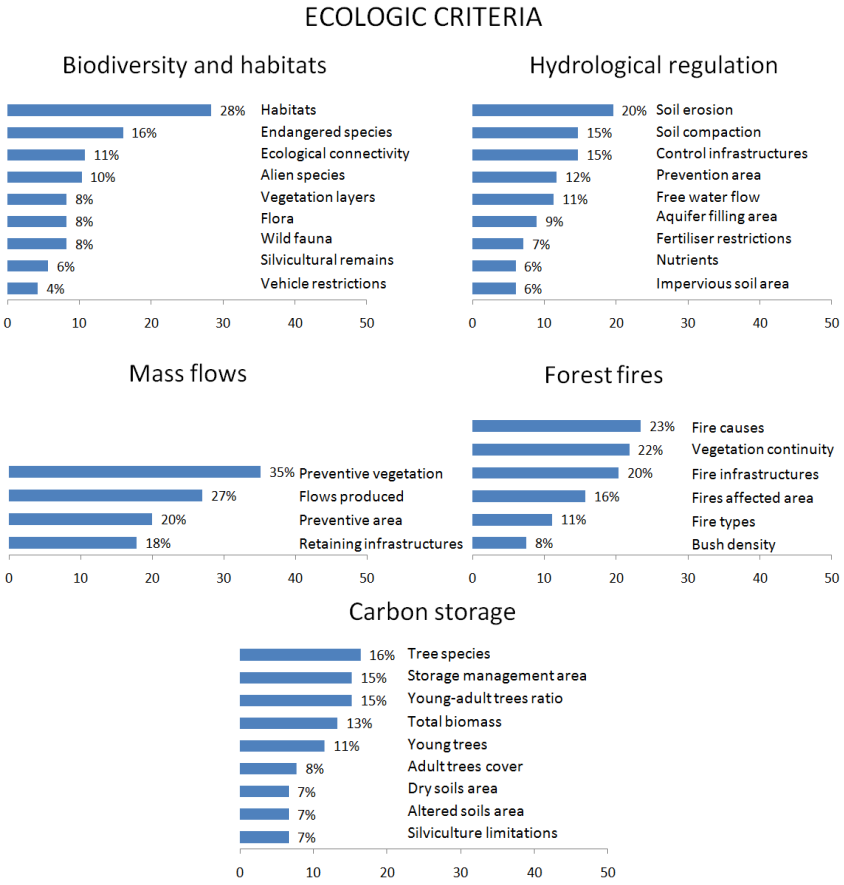

Figure 3. Weights of the indicators of the ecologic criteria.

times more important than alternative C. AHP cannot cope with the fact that A is twelve times C. Clearly, such respondent would rearrange her/his valuations afterwards, but according to Macharis *et al*. (2004) this is an artificial arrangement that the procedure applied in this research avoided. Concerning the reference indicators, it was acknowledged from the beginning of the study that the selection may influence the results in all cases, so that a random selection was considered suitable.

As conclusions, SFM takes into account other services and goods provided by forests apart from wood. Indicators for Mediterranean conditions were verified and proposed using AHP. These indicators are adapted to an ecosystem services framework, and so, there is a balance in the indicators among economic, social and ecologic issues. SFM under these circumstances at the FMU level might consider: incomes from ecosystem services, new markets for underexploited products, visual and cultural character of landscapes, facilities for education and recreation, natural habitats conservation, forest cover structures for biodiversity and erosion prevention, forest fires regulation and carbon sink function improvement.

MCA techniques help to verify and make changes to a preselected list of elements. By means of AHP, indicators were verified and reduced from 103 to 94; it was suitable for experts because the topics were within their understanding and prioritising indicators required conscious valuations.

It was the aim of this research to get a hierarchy of a set of indicators previously identified. The simplification of the AHP method proposed was meant to obtain a higher number of responses. Authors were aware of the potential weaknesses and inconsistencies that this approach may bring, but this work intended to be an exploratory dive into the considerations and priorities of sustainable forestry under Mediterranean conditions. Further insights into the topic are needed.

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