



Towards harmonized assessment of European forest availability for wood supply in Europe



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ABSTRACT

The supply of wood in Europe on a sustainable basis is highly relevant for forestry and related policies, particularly in relation to (i) analysing global change mitigation strategies and carbon accounting (ii) establishing realistic forecasts and targets for wood resources, biomass and renewable energy and (iii) assessing and supporting strategies for an increased use of wood.

Therefore, it is relevant to have robust information of the availability for wood supply. The main aim of this paper is to harmonize the concept of 'forest available for wood supply' (FAWS) at European level.

The data employed in this study was acquired through two questionnaires. The first questionnaire, conducted under the framework of COST Action FP1001 and a second questionnaire was completed by national correspondents and members of the UNECE/FAO.

The analysis showed that reasons for the exclusion of forest from FAWS are diverse. Legal restrictions and specifically 'Protected areas' are considered by 79% of the countries while very few countries consider economic restrictions.

Abbreviations: (EU), European Union; (NFIs), National Forest Inventories; (SDGs), Sustainable Development Goals; (FAO), Food and Agriculture Organization of the United Nations; (C&I), Criteria and Indicators; (SFM), Sustainable Forest Management; (FRA), Global Forest Resources Assessment; (TBFRA), Temperate and Boreal Forest Resources Assessment; (FAWS), Forest available for wood supply; (FNAWS), Forest not available for wood supply; (SoEF), State of Europe's Forests; (EFSOS), European forest sector outlook study; (ToS), Team of Specialists; (UNECE/FAO), United Nations Economic Commission for Europe and The Food and Agriculture Organization of the United Nations.

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A new FAWS reference definition is provided and the consequences of using this new definition in eight European countries were analysed. Application of the proposed definition will increase consistency and comparability of data on FAWS and will result in decreasing the area of FAWS at a European level.

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1. Introduction

The availability of wood is currently an important concern relevant for several forest and related strategies. Discussions on climate change and post-Kyoto negotiations are taking place, including the estimation of carbon storage in forests, energy from wood and harvested wood products (COST 4137/10, 2010). Wood is a key resource to be taken into account for climate change mitigation because it can store carbon as well as be used as a replacement to fossil fuels. Additionally, availability of wood supply is important due to the rapid growth in demand for wood (EC, 2013), including for energy production (EC, 2009).

The importance of reporting on the availability of forests for wood supply has gained more importance in the context of the recently adopted Sustainable Development Goals (SDGs) and related indicators (Sachs, 2012). However, while the process has not yet been concluded, it can be expected that the forest available for wood supply (FAWS) will be central for the assessment of the sustainability level of forest management.

National Forest Inventories (NFIs) are the main information source for the estimation of FAWS as well as the growing stock at national level. The methods used to estimate FAWS nationally, are generally based on the exclusion of forest areas according to restrictions (e.g. protected areas, accessibility, etc.).

FAWS is one of the basic attributes collected through international forest reporting. In 1948, 'productive' and 'unproductive' forests were included in the first world report on forest resources, published by the Food and Agriculture Organization of the United Nations (FAO). Over time, meanings and contexts have changed; e.g. the set of applied terms included (i) 'productive' and 'unproductive' (ii) 'operable' and 'inoperable' (iii) 'exploitable' and 'non exploitable' forests. Despite the developing needs and context, 'availability for wood supply' has remained one of the key characteristics of forest reporting and assessment.

Terms and definitions of FAWS and 'Forest not available for wood supply' (FNAWS) established by FAO (1948) were modified in the Kotka III meeting (Finland, 1996) by the expert consultative and advisory group for The Global Forest Resources Assessment 2000 (UNECE/FAO, 2001a). The definition of FAWS established by Kotka III was the following: "Forest where any legal, economic or specific environmental restrictions do not have a significant impact on the supply of wood". Additionally, this definition was further qualified by specifying that FAWS includes "areas where, although there are no such restrictions, harvesting is not taking place, for example in areas included in long-term utilisation plans or intentions". In contrast, FNAWS was defined as "Forest where any legal, economic or specific environmental restrictions prevent any significant supply of wood".

Then, reporting on availability of wood supply was also addressed by the processes to develop criteria and indicators (C&I) for sustainable forest management (SFM). Related information appeared under the two major C&I systems applied for temperate and boreal countries, i.e. FOREST EUROPE (MCPFE, 2002) and Montréal Process (Montréal Process, 2009). In the pan-European system (FOREST EUROPE) the 'availability for wood supply' is not a separate indicator but it serves as a means to breakdown several indicators, including: forest area, growing stock, forest age/diameter structure, fellings and growth. A direct reference to 'availability for wood supply' was provided under Indicator 3.1 (Increment and fellings) according to which this indicator "highlights the sustainability of timber production over time as well as the current availability and the potential for future availability of timber".

In addition to the Global Forest Resources Assessment 2000 (UNECE/FAO, 2001a), the FAWS definition established in Kotka has been used for

reporting in Temperate and Boreal Forest Resources Assessment (TBFRA) 2000 (UNECE/FAO, 2001b), in the State of Europe's Forests (SoEF) 2003 (MCPFE, UNECE and FAO, 2003), SoEF 2007 (MCPFE, UNECE and FAO, 2007), SoEF 2011 (FOREST EUROPE, UNECE and FAO, 2011) and SoEF 2015 (FOREST EUROPE, 2015).

European forests (excluding the Russian Federation) cover an area of 210 million ha (32.8% of land area), and the majority of this area (79.3%) is reported as being available for wood supply. The proportion of FAWS related to forest area of European sub-regions are reported as follows: Central-West 94.1%, South-West 81.0%, North 78.0%, and South-East 74.1%. Central-East Europe (70.4%) is the sub-region with the lowest share of forests available for wood supply (FOREST EUROPE, 2015). Nevertheless, the national estimates reported to FOREST EUROPE that are aggregated to a sub-region are of limited comparability, as will be shown in this study.

Trends in FAWS are highly relevant for analysing the productive capacity of Europe's forest resources, however long term comparability is strongly hampered by a lack of consistency among data between countries and reporting methods over reporting cycles. An attempt to overcome these obstacles is the study by Gold (2003), which was prepared in the course of the production of the European forest sector outlook study (EFSOS I) (UNECE/FAO, 2005) and presents long-term historical trends in forest area for the majority of European countries from the 1950's to 2000. The area of FAWS in these countries increased by about 6% percent over this period. However, the study did not address the problem of data comparability between countries.

It is important to highlight that there are large-scale models such as the European Forest Information Scenario model (EFISCEN) (Nabuurs et al., 2007; Sallnäs, 1990; Schelhaas et al., 2007; Verkerk et al., 2011), which simulate future FAWS resources under assumptions of future wood demand and a given management regime (rotation lengths, residue removal). These large-scale models generally use NFI data as the basis for calculations and enable the assessment of impacts of different policy and management strategies at European level.

The initial objective of international reporting on the availability of wood supply was apparently clear: to distinguish areas (and related variables) where wood could be harvested from those where it could not. However, the managerial approaches are much more complex and the provision of consistent national data according to the proposed definition and classification of forest area as available or not available for wood supply poses many challenges. National correspondents and other specialists in forest reporting lack detailed reference definitions and restriction thresholds.

This paper aims to: (i) discuss and clarify the concept of FAWS; (ii) analyse the consistency of international information on FAWS; (iii) and provide recommendations for NFI data harmonization derived at the European level. The proposed definition of FAWS outlined will contribute to the harmonization of NFI results and the consistency of data collected internationally thereby enhancing the quality of the political decisions not only in forest management but also in the wood and energy sectors.

2. Material and methods

The data employed in this study to assess possible harmonization of FAWS at European level were acquired through two different sources: 1) a questionnaire and accompanying country status reports produced by NFI experts under the framework of COST Action FP1001 (*Improving data and information on the potential supply of wood resources: a*

European approach from multisource national forest inventories) and 2) a questionnaire completed by the UNECE/FAO Team of Specialists (ToS) on Monitoring Sustainable Forest Management (SFM) hereafter referred as ToS-SFM questionnaire.

2.1. COST Action FP1001 questionnaire

The COST Action FP1001 questionnaire was based on procedures adopted by countries for the estimation of FAWS areas and growing stock. Respondents to this questionnaire included NFI delegates from 29 European countries (Fig. 1). The questions were designed to acquire information regarding: (i) the concept and national definitions of FAWS through open questions; (ii) the willingness to find a harmonized definition and adopt it through single-choice questions; (iii) the aim of FAWS estimation for national and international reporting through open questions; (iv) a description of restrictions and their thresholds considered in each country to define FAWS through single-choice questions; (v) the methodology and sources of information used for the calculation of FAWS estimates in a combination of single-choice and open questions. Four restriction classes were proposed to estimate FNAWS and FAWS: (i) legal; (ii) physiographic; (iii) environmental and biodiversity conservation; (iv) management and harvesting technology. Three key questions in the questionnaires were analysed: (i) different restrictions used for international reporting for each country to estimate FAWS (national definition); (ii) the relative importance of each restriction considered by different countries, even if they were not included in their national definition; (iii) the availability of information for each restriction within each country.

2.2. ToS-SFM questionnaire

The questionnaire completed by national correspondents and the UNECE/FAO ToS on Monitoring SFM members was developed in 2012 and was answered by 30 European countries (Fig. 1). This questionnaire included a multiple-choice question for which respondents were asked to identify which of the following seven different forest categories were excluded from FAWS when reporting for SoEF 2011: 'protected areas',

'protective forest', 'key habitats', 'areas with low productivity/low wood quality', 'areas with high harvesting costs/poor access' and 'other restricted areas' (e.g. military). Respondents were also asked in an open question whether these categories were expected to be excluded in future reporting.

2.3. Data analysis and case studies

Responses to both questionnaires were summarised using percentages estimated using the number of countries and also their forest area to evaluate the results.

Taking into consideration both sources of information, a reference definition for FAWS was established according to COST E43 recommendations (Vidal et al., 2008) applying a consensus process including all NFIs involved in COST FP1001. This reference definition, agreed by European NFIs, was established with the following objectives: it must be concise, data or information with adequate accuracy must be available and methods to convert estimates from the national definitions to the reference definition must be available or be established (Ståhl et al., 2012).

Additionally, economic restrictions were analysed by NFI experts (under the framework of COST Action FP1001), who defined through their expert judgment, a reference threshold range (delimited by a maximum and a minimum) of the restrictions for European countries indicating the critical interval values in European countries to define an area as FAWS or FNAWS.

Finally, to demonstrate the impact of the new reference definition, the change in FAWS area in relation to the total area of forest was evaluated. A comparative analysis was undertaken between the reported area of FAWS in SoEF2010 (FOREST EUROPE, UNECE and FAO, 2011), SoEF2015 (FOREST EUROPE, 2015) and results according to the new reference definition. This analysis was performed for eight representative European countries: Iceland, Ireland, Italy, Portugal, Romania, Spain, Sweden and Switzerland. The eight countries included in this study were selected as they vary in size, climatic conditions, topography, and conditions of forest sector. In Iceland, the NFI was not launched until 2005 and the comparison was completed using a subsample of the total forest area (i.e. cultivated forest and the natural birch forest). Data for the other countries were collected for the whole forest area.

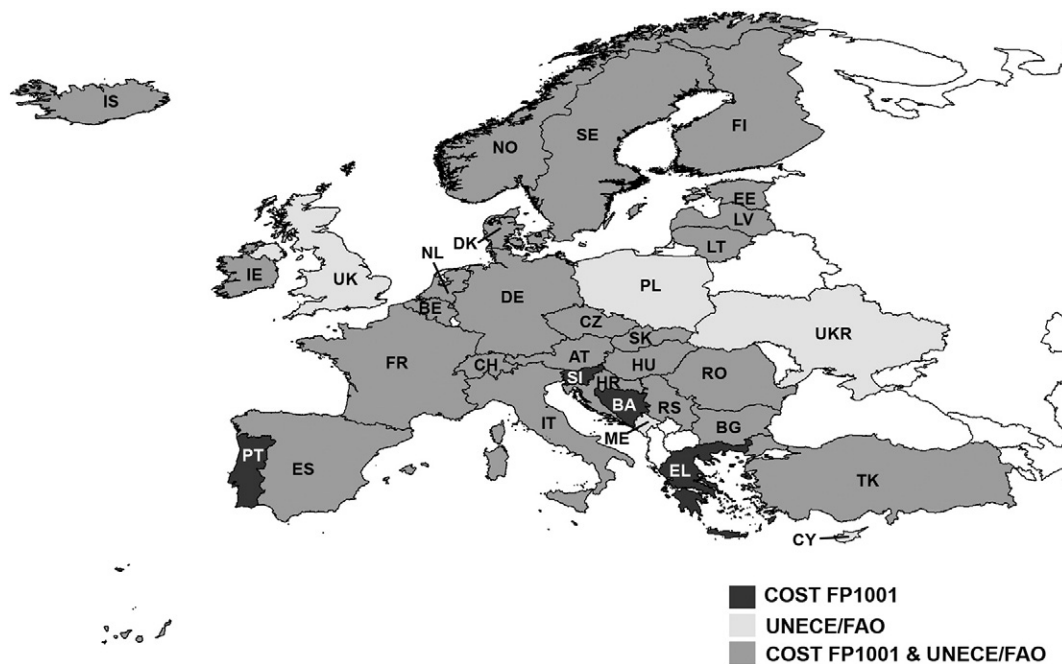


Fig. 1. Countries participating in COST Action FP1001 questionnaire on forest available for wood (supply by 29 European countries) and questionnaire completed by members of the UNECE/FAO Team of Specialists on Monitoring Sustainable Forest Management (30 countries). European countries answering only COST FP1001 Action questionnaire are shaded in black colour, countries answering only the UNECE/FAO questionnaire are shaded in light grey while European countries answering both questionnaires are shaded in grey.

Table 1
National definitions of forest available for wood supply of countries participating in COST Action FP1001.

Country	National definition
Bosnia and Herzegovina	Forests with productive character.
Belgium	National forest area with the exception of the forest with slope above 15% non-productive forest land and additionally roads, mud, moors, pools and rivers which are part of the forest.
Switzerland	Forest where tree felling is physically and legally possible, even if it is difficult and not economically profitable. No condition on site productivity
Czech Republic	Forest land according with forest law considering its prevalent function.
Germany	Forest without significant restrictions on wood. Restrictions on use exist if the possible uses of timber cannot all be taken advantage of. This includes restrictions on the use of timber both due to legal regulations or other external reasons. Restrictions on use categories: no restriction on the use of timber; use of timber not authorized or not to be expected; approx. 1/3 of the usual harvest to be expected; approx. 2/3 of the usual harvest to be expected External reasons for the restriction on use categories: no external restrictions on use; nature conservation; protection forest; recreational forest; other external reasons Internal reasons for the restrictions on use categories: no internal restrictions on use; split ownership of uneconomic size; stand-alone location; insufficient accessibility; site characteristics, wet location; little expected yield (mean total increment <math><1\text{ m}^3/\text{yr} \cdot \text{ha}</math>); areas protected at owners discretion (e.g. natural forest reserves); other internal reasons
Estonia	All forests not strictly protected.
Greece	Productive or Industrial forests
Spain	Forest land where legal restriction, site conditions and specific environmental restrictions has a significant impact on the supply of wood. Legal restrictions comprise all the forest area apart from Protected Areas (National parks, nature parks, reserves and others).
Finland	Similar to SOEF definition. For each specific LU category or protection programme is defined, is it a) fully AWS, b) semi-AWS c) non-AWS
France	Forest where tree felling is physically and legally possible, even if it is difficult and not economically profitable. No condition on site productivity
Ireland	Forest where any legal, economic, or specific environmental restrictions do not have a significant impact on the supply of wood. Includes: Areas where, although there are no such restrictions, harvesting is not taking place, for example areas included in long-term utilisation plans or intentions. To date no consideration has been given to economic aspects.
Lithuania	Exploitable forest with usual environmental restrictions. Includes protective (III group of forests) and commercial (IV group) forests, excluding forests with nature monuments, zones surrounding nests of rare birds, other valuable cultural, historical objects.
Latvia	Forests where forest management as such or specific measures are not limited by regulations, including environmental restrictions (like buffer zones), nature conservation restrictions or regional planning (like cultural heritage) related restrictions.
Netherlands	Forests including even aged and uneven aged standing forest, standing forest in transition (plantation appearance to more natural forest) and clearcuts. On top of this the area of standing forest that is set aside as strict forest reserves as subtracted from the area. If actual harvesting takes place does not have any consequences for the allocation to FAWS.
Portugal	It comprises all the forest area, with the exception of cork and holm oak areas, in which wood harvest has strict restrictions and the "Laurisilva" forest, and conservation areas where harvesting is strictly prohibited.
Romania	Forest with production functions, situated at a distance smaller than 1.2 km from a (forest) road.
Serbia	In FAWS category belongs all forests which are not in first regime of protection (rare species of flora and fauna, cultural and heritage areas) and also forests which are accessible for forest mechanization
Slovenia	Forests are divided into multipurpose forests, special purpose forests with legal restrictions which exclude or limit wood production, forests with protective functions.
Turkey	Similar to SOEF definition.

3. Results

3.1. National definitions analysis. COST action FP1001 questionnaire

The analysis of the COST Action FP1001 questionnaire revealed that 66% of the countries already have a national definition for FAWS (encompassing 63% of the total forest area of the analysed countries), while 24% of the countries have adopted the SoEF definition (FOREST EUROPE, UNECE and FAO, 2011). Only 10% of the countries have not developed a FAWS definition for national purposes (although the SoEF definition is used for international reporting). National definitions of FAWS differ considerably (Table 1), the most prevalent restrictions vary from legal, to environmental, to economic or a combination of all three. For instance, the Romanian national definition of FAWS is "Forest with productive functions according to technical norms for forest management planning, situated at a distance of less than 1.2 km from a forest road" while the Estonian definition is "All forests not strictly protected" and the definition applied in France and Switzerland is "Forest where tree felling is physically and legally possible, even if it is difficult and not economically profitable. No condition on site productivity". Already these three definitions demonstrate the great diversity in the concept of FAWS.

The "availability" component of FAWS was not equally interpreted by all countries as it could be considered as 'potential availability', 'current availability' or even as a period of time such as the rotation period (Fig. 2). Austria considers this concept within a period of time, while the rest of the countries are divided into two almost equal groups; either potentially or currently availability. Some countries (Croatia, Denmark,

Finland, Slovenia and the Netherlands) considered both, potential and current availability, in their assessment.

3.2. The willingness of countries to reach a harmonized reference definition. COST Action FP1001 questionnaire

Another important aspect is the willingness of countries to agree on a harmonized reference definition and then adopt it. >85% of the countries (representing 83% of the total forest area of the considered countries) indicated the possibility of adopting of the SoEF definition compatible with national information sources, while 90% found it feasible to adopt a future agreed reference definition. It is important to note that 55% of countries estimate FAWS only for the international reporting, while 45% also use this information for national purposes.

3.3. Restrictions to estimate forest available for wood supply. COST Action FP1001 questionnaire

The restrictions taken into account by the different countries are diverse (Fig. 3). More than half of the countries consider legal restrictions associated with 'Protected areas' and 'Protected species' as well as physiographic restrictions, 'slope' and 'accessibility'. On the other hand, <20% of the countries use management and harvesting restrictions such as 'harvest technology' and 'harvest cost'. As regards to the percentage of forest area in which these categories are taken into account, the values are quite similar.

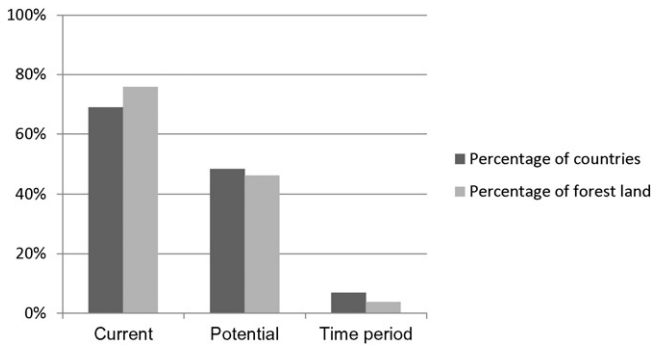


Fig. 2. Interpretation of the term “available” in ‘forest available for wood supply’ by 29 European countries. Percentage of the countries and percentage of the forest considering FAWS in terms of “potential”, “current” or a time period (rotation or management plan).

It is important to highlight that restriction thresholds are very different depending on the country. ‘Protected areas’ and ‘protected species’ are related to country specific law and ecological conditions.

Some restrictions such as ‘accessibility’ have quite different definitions and thresholds. As already mentioned, in Romania an area is considered accessible when the distance of the forest compartment is < 1.2 km from a forest road. In Italy, accessibility and wood supply feasibility are estimated subjectively by the NFI crews in the field based on local conditions, although no specific variables and thresholds are given.

As regards to the restriction ‘slope’, Slovenia applies a threshold of 35% while Spain uses the exploitation threshold of 45–50%, which in the Atlantic area can reach 75–80% and in Switzerland, steepness of slope is not a restriction for wood harvesting.

The importance of each restriction considered by the different countries has also been analysed in terms of the percentage of the total number of countries that applied these restrictions, and the percentage of their forest area (Fig. 4). Regarding the percentages of countries, the figures are the following: ‘protected areas’ (93%), ‘slope’ (86%), ‘accessibility’ (79%), ‘riverbank’ (76%), ‘protected species’ (76%), ‘erosion’ (69%),

‘age or diameter classes’ (62%), ‘cultural’ (59%), ‘flooded areas’ (55%) and ‘ownership’ (52%). Restrictions related to ‘harvest cost’ and ‘harvest technology’, ‘spiritual interest’, and ‘expected silvicultural treatment’ were only considered as relevant by a small number of countries. Fig. 5 shows the information available to estimate FAWS for each restriction. It is important to note that harvest cost and harvesting technology were only taken into consideration by a small number of countries and in a small part of the forest area (24% and 29% respectively for ‘harvest cost’ and 31% and 26% respectively for ‘harvesting technology’).

3.4. Sources of information to estimate forest available for wood supply. COST Action FP1001 questionnaire

The main sources of information used by the different countries to estimate the area of FAWS and FNAWS are NFI plots (52%) and national maps (42%), although other sources are sometimes used (Fig. 6). Most of the restrictions are estimated with a similar percentage for both main sources of information. A higher percentage of the data regarding ‘accessibility’, ‘age or diameter classes’, ‘slope’ and ‘expected wood quantity’ are estimated from NFI plot information. As regards the sources of information available to estimate the restrictions which are not included in national FAWS definitions, 56% could be estimated from NFI plot information while maps could be used in 39% of the countries (Fig. 7).

3.5. Analysis of restrictions to estimate forest available for wood supply. ToS on monitoring SFM questionnaire

The analysis of the ToS questionnaire revealed that in 50% of the countries ‘protected areas’ are excluded from FAWS. However 70% of all countries are able to exclude protected areas from FAWS in future assessments representing the same percentage in forest area (Table 2). Each one of the following area classes is excluded from FAWS estimation by one third of all countries: ‘protective forests’, ‘key habitats’ and ‘other restricted areas’ (e.g. military). ‘Protective forests’ are managed in different ways depending on the protective function and on the

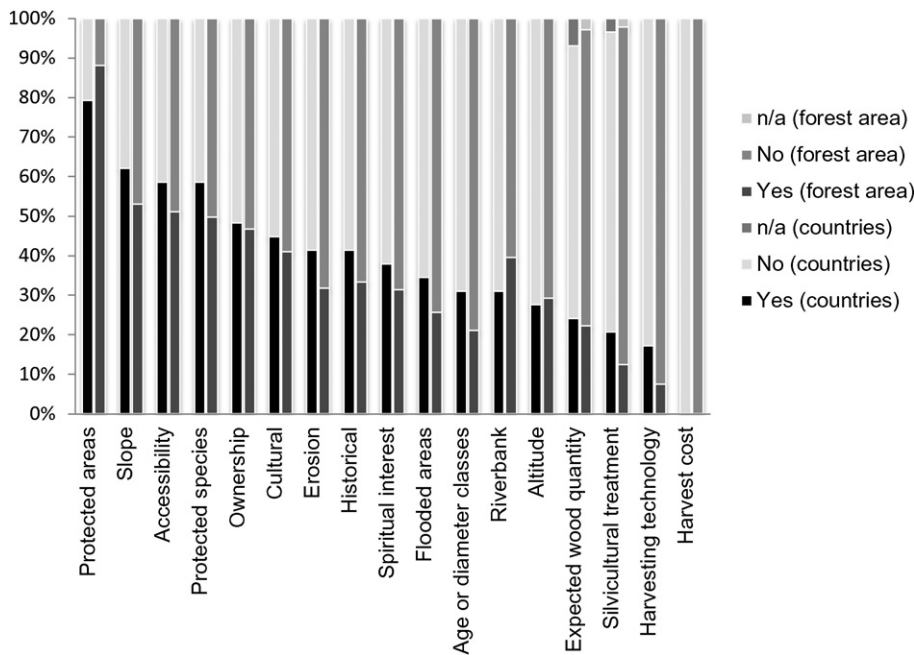


Fig. 3. Percentage of 29 European countries considering each restriction in their national definition as well as percentage of forest area in which each restriction is considered. The first bar graph shows the percentage of the number of countries while the second bar shows the percentage of forest area. Yes (countries): percentage of countries considering the restriction; No (countries): percentage of countries not considering the restriction; n/a (countries): information not available. Yes (forest area): percentage of forest area in which the restriction is considered; No (forest area): percentage of forest area in which the restriction is not considered. n/a (forest area): information not available.

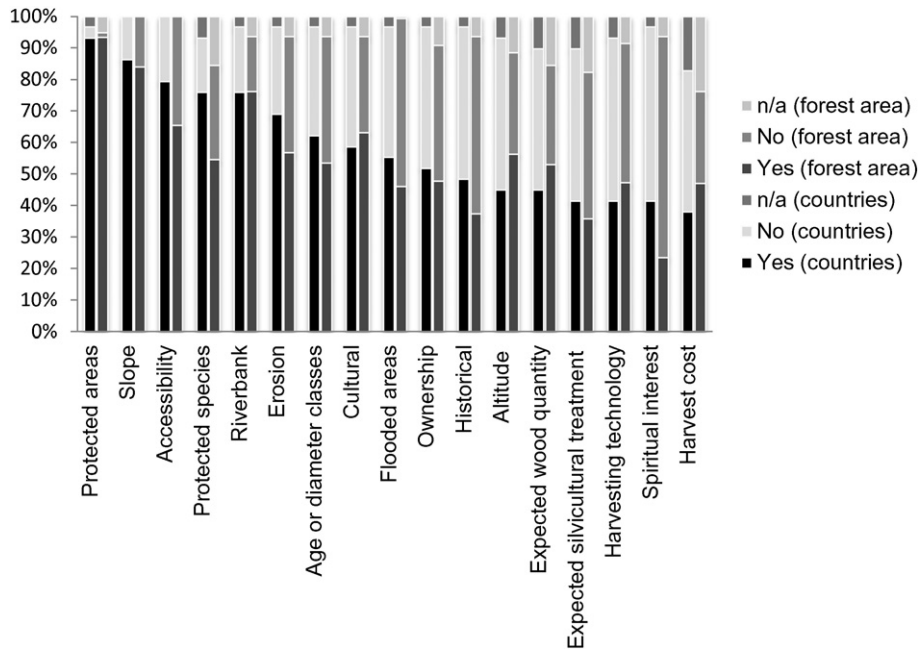


Fig. 4. Percentage of 29 European countries considering each restriction relevant for their country and percentage of forest area in which each restriction is considered relevant. The first bar graph shows the percentage of the number of countries while the second bar shows the percentage of forest area. Yes (countries): percentage of countries considering the restriction relevant; No (countries): percentage of countries considering the restriction not relevant; n/a (countries): information not available. Yes (forest area): percentage of forest area in which the restriction is considered relevant; No (forest area): percentage of forest area in which the restriction is considered not relevant. n/a (forest area): information not available.

management regime. In this paper, when protective forest is mentioned, it refers to those areas where harvesting is currently not taking place or is not significant. The number of countries considering 'protective forests', 'key habitats' and 'other forest' in FAWS estimation is expected to increase by 10–20% in future (due to the information currently available, Table 2). On the other hand, 'areas with low

productivity or low quality of wood', which are excluded from FAWS were reported by 20% of countries and could increase to 27% in the future. 'Forest areas with high harvesting cost or poor access' excluded represent 17% of the total FAWS area (or 12% of the forest area) nationally and this figure could also increase to 27% of the total FAWS area (or 16% of the total forest area) in the future.

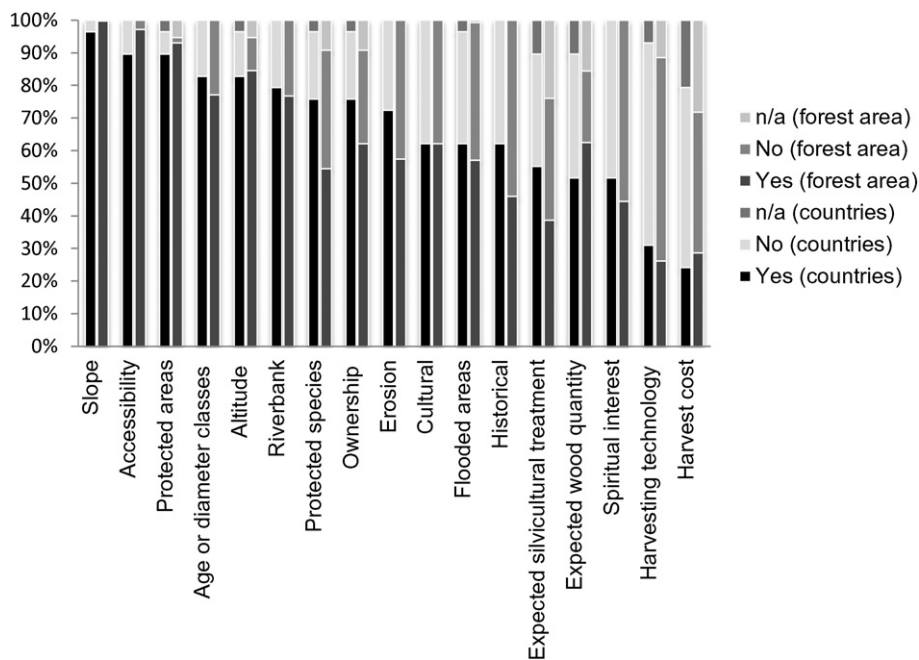


Fig. 5. Information availability. Percentage of 29 European countries which have enough national information to estimate each restriction. The first bar graph shows the percentage of the number of countries while the second bar shows the percentage of forest area. Yes (countries): percentage of countries having available information to estimate the restriction; No (countries): percentage of countries not having enough information to estimate the restriction; n/a (countries): information not available. Yes (forest area): percentage of forest area in which countries have available information to estimate the restriction; No (forest area): percentage of forest area in which countries have not enough information to estimate the restriction. n/a (forest area): information not available.

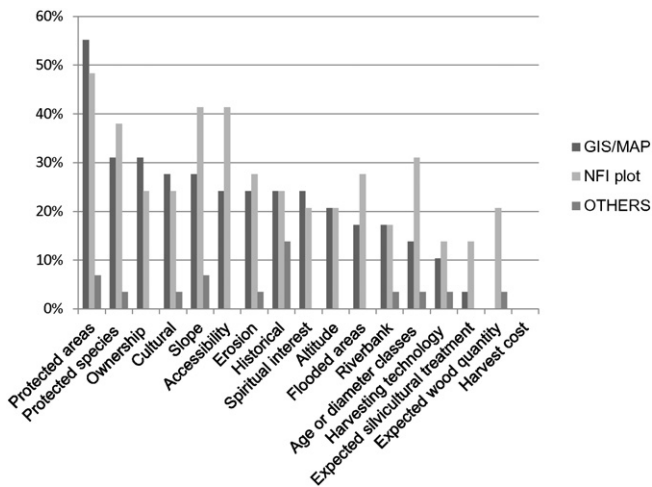


Fig. 6. Percentage of countries using different sources of information to estimate the restrictions of FAWS considered in their national definitions.

3.6. FAWS reference definition

With regard to the international definitions and the results obtained in a European context, a reference definition for FAWS including details on restriction classes as well as a number of recommendations for their assessment has been proposed:

Forests where there are no environmental, social or economic restrictions that could have a significant impact on the current or potential supply of wood. These restrictions could be based on legal acts, managerial owners' decisions or other reasons.

- Environmental restrictions should consider: protected areas, protected habitats or species, and also those protective forests meeting the above requirements. Age or diameter class restriction should not be taken into account (except in the case of protected ancient forest).
- Social restrictions include restrictions to protect aesthetic, historical, cultural, spiritual, or recreational values as well as areas where the owner has made the decision to cease wood harvesting in order to focus on other goods and services (e.g. leisure, landscape, aesthetic value).
- The economic restrictions are considered as those affecting the economic value of wood utilisation (profitability). These includes:

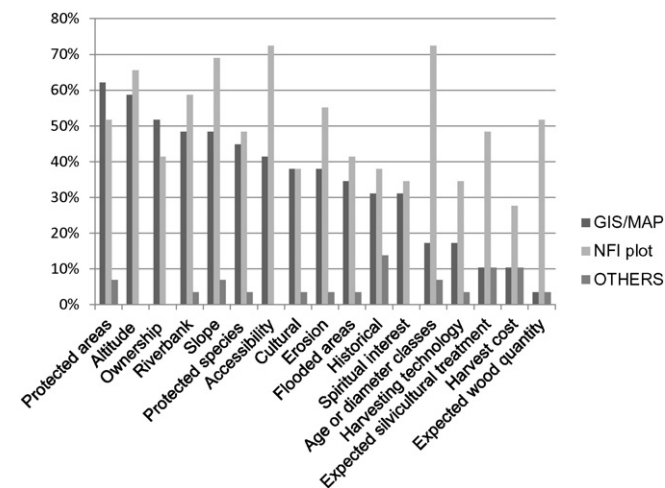


Fig. 7. Percentage of countries using the different sources of information that could be used to estimate FAWS restrictions.

accessibility, slope and soil condition. Short-term market fluctuations should not be considered.

Reporting notes:

A significant impact occurs when harvesting is totally prohibited or when restrictions severely limit the feasibility of cuttings for commercial purposes.

When restrictions do not severely limit commercial utilisation of wood in an area, it should be considered available for wood supply even if current harvesting is for auto-consumption or no harvest at all is taking place. Conversely, when restrictions limit the feasibility of commercial wood utilisation, even if there is occasional cuttings for auto-consumption or other small-scale interventions of a non-commercial nature, the forest should be considered as FNAWS.

Regarding the assessment of availability for wood supply, the following recommendations were proposed for reporting: (i) the three different categories should be accounted for separately if possible (environmental, social, and economic); (ii) restrictions considered for each category should be detailed if possible (e.g. protected areas, protected species).

Table 3 shows the reference maximum and minimum thresholds for the proposed aspects affecting profitability of wood utilisation and which are therefore used to assess economic restrictions. Expert judgment was used to define the proposed aspects in the framework of COST Action FP1001 and these account for differences among European countries.

3.7. Impact of the reference definition on the assessment of FAWS

The proposed reference definition was applied in a sub-set of countries and compared to the areas of forest and FAWS reported in SoEF 2010 (FOREST EUROPE, UNECE and FAO, 2011) and SoEF 2015 (FOREST EUROPE, 2015). In the case of Iceland, Portugal, Spain and Sweden the new reference definition of FAWS results in a lower ratio (FAWS area/forest area) than the one reported for SoEF (Table 4) due to the fact that some of the restrictions were not considered for SoEF reporting. In the case of Italy, the reference definition fit the national definition. The greatest differences between both definitions are observed in Iceland, Spain and Portugal. There are still more aspects (like the inclusion or not of social restrictions) showing that the figures considering the reference definition need to be further harmonized to obtain comparable European information (Table 4).

4. Discussion

The division of all forests into either 'available' or 'not available' for wood supply is a vital part of the forest assessment process. Since the beginning, it has been important for regulating harvest levels and for evaluating the efficiency of timber production (EC, 2013). Its importance increased, with the growing role of carbon management and related reporting.

FAWS is considered one of the basic characteristics collected through international forest reporting, however, different countries have applied the international definitions provided by FRA 2000 (UNECE/FAO, 2001a) and SoEF (FOREST EUROPE, UNECE and FAO, 2011) in quite different ways. As a result, the estimations provided by the pan-European reporting do not facilitate comparisons between national figures. To some extent this could be the result of the lack of a clear specification if information about current or potential availability of timber is expected, which results in different interpretations of the definition by various countries. Gold (2003) showed inconsistencies for international reporting on FAWS in long-term historical data series indicating the need of addressing the issue of comparability of data between different countries.

Table 2

Percentage of 30 countries and percentage of their forest area considering each forest area classification (protected areas, protective forest, key habitats, other restricted areas e.g. military, areas with low productivity or low wood quality, areas with high harvesting costs or poor access, other forests e.g. recreational) in their national estimation of forest available for wood supply and the percentage of the countries and percentage of their forest area which have information available to estimate each one of the forest area classes. ToS on Monitoring SFM questionnaire.

	Considered in national definition		Available information	
	Ncountries (%)	Forest area (%)	Ncountries (%)	Forest area (%)
Protected areas	50	64	70	76
Protective forests	33	36	47	37
Key habitats	33	47	40	51
Other restricted areas (e.g. military)	30	42	47	58
Low productivity or low wood quality	20	25	27	37
High harvesting costs or poor access	17	12	27	16
Other forests (recreational)	45	50	53	62

The questionnaire analysis reveals that the main issues affecting the accuracy and consistency of FAWS estimates among countries are the different interpretations of the terms “availability” and “significant” included in the international definitions (FOREST EUROPE, UNECE and FAO, 2011). Also the availability and accuracy of the information used nationally to generate restriction estimates for reporting is an impediment to harmonization.

Confusion exists with regard to the time frame for assessing FAWS and therefore different interpretations of the “availability” term are prevalent. Opinions vary as to whether it should be assessed in accordance with the current situation, potential situation or a given time period. Additionally, the SoEF (FOREST EUROPE, UNECE and FAO, 2011) definition of FAWS includes “areas where harvesting is currently not taking place, for example areas in long-term utilisation plans or intentions”. This means that the restriction “age or diameter class” (i.e. exclusion of young forests below commercial felling thresholds of FAWS) should not be considered to determine FAWS area. Consequently, the restriction “age or diameter class” was not considered in the reference definition of FAWS (with the exception of protected ancient forests). Nevertheless this concept is interpreted in different ways. For example, 30% of the countries include this restriction in their national definition and >60% consider it to be relevant, even if it is not included in their definition. Additionally, it should be highlighted that some restrictions may change over time (e.g. accessibility of forest or legal restrictions such as protected areas) thus affecting the FAWS estimates.

An interpretation of “significant impact on wood supply” is not included in either the SoEF definition or explanatory notes (FOREST EUROPE, UNECE and FAO, 2011). Such uncertainty allows countries to interpret the definition in different ways. For example, Ireland stresses that in theory, they “do not have any areas which are not available for wood supply” as there are no strict laws that completely exclude harvesting operations. In Switzerland, harvesting can theoretically occur in almost all forests except in reserves/national parks. For this reason, the reference definition specifies that a significant impact occurs when harvesting is totally prohibited or when restrictions severely limit the feasibility of cuttings for commercial purposes. Even more, it has been stated in the reporting notes when to consider forest areas as FAWS or FNAWS. When restrictions limit the feasibility of commercial wood utilisation, even if there are occasional cuttings for auto-consumption or other small-scale interventions of a non-commercial nature, the

forest should be considered as FNAWS. Nevertheless, there are certain countries such as Bosnia and Herzegovina or Greece where FAWS embraces all forest defined as by national definitions as ‘productive’.

Availability of information as well as its accuracy is often unclear and must be further analysed. In some countries FAWS is assessed through forest management plans which do not cover the whole forest area. Moreover, data needed for the assessment of all required restrictions is unavailable in many countries. Especially for the assessment of ‘economic restrictions’. Site related restrictions have been included in the reference definition as proxy: accessibility, slope and soil condition. However it would be relevant to include a restriction considering profitability. Growth and productivity were evaluated, but there are special cases such as low growth, high prices and high growing stock where these indicators are not necessarily restrictions. Nevertheless there are countries, such as Lithuania or Norway, that include productivity criteria as a restriction. As a consequence, potential wood quality (Zhang, 2003) in situ was proposed as a possible suitable indicator due to the possible impacts of its attributes on wood utilisation.

Furthermore, the delimitation of the forest area that should be excluded from FAWS is not defined for certain restrictions (e.g. protected landscape areas in Italy where the protection law exists and specifies the landscapes but not the boundaries of these landscapes).

The harmonization of each restriction is highly challenging, even when all the information is available. For instance, ‘slope’ is available for most of the countries but it can be understood as plot slope, average slope, etc. Another restriction for which most countries have information on is that of ‘protected areas’. In this case, it is not clear which classification is used and how the classes are applied to separate areas where active management is not allowed. As a result, national interpretation/classification is currently required to determine FAWS areas.

Definitions must be more concise to avoid overlaps. In the SoEF (FOREST EUROPE, UNECE and FAO, 2011) definition, overlaps between the considered restrictions might occur, for instance between legal and environmental restrictions in ‘protected areas’ or ‘protective forest’. Therefore it is important to differentiate three dimensions in the reference definition: the wood supply (current and potential), the nature of the restriction (environmental, social and economic), and the character of the restriction (legal, administrative, managerial/owner’s decision and others). In the reference definition two main recommendations were proposed for reporting if possible: (i) the nature of the restriction should be accounted for separately; (ii) restrictions considered for each category should be detailed (e.g. protected areas, protected species). These metadata will improve data comparability of national estimates. It is noteworthy to mention that there are links between nature conservation measures (e.g. management plans for Natura 2000 sites) and the restrictions that should be considered for FAWS estimation.

The impact of applying the proposed FAWS reference definition on the countries, included in the analysis, shows that this definition is crucial to provide comparable information and it will affect (or has already

Table 3

Maximum and minimum common thresholds of economic restrictions to estimate FAWS established through expert judgment in the framework of the COST Action FP1001.

Restriction	Unit	Minimum	Maximum
Slope	%	35	140
Distance from road	m	400	2000
Mean annual increment	(m ³ /ha * yr)	1	3

Table 4
Percentage of Forest available for wood supply (FAWS) of the total forest at national level in seven European countries according to SoEF 2010; SoEF 2015 and the Reference definition established in COST Action FP1001. The comments are related to the Reference estimation and include those aspects considered to estimate FAWS value implying that even this estimation is not completely comparable between countries (e.g. productivity criteria is considered only in two countries). The last column indicates in which countries the Cost Action FP1001 has already influenced FAWS estimation in the National Forest Inventory. n/a: information not available.

Country	SoEF 2010 (%)	SoEF 2015 (%)	Reference definition (%)	Comments	Influence cost action FP1001
Iceland	97	52	44		Yes. New field data sampling on restriction of FAWS
Ireland	n/a	84	84		Yes. Definition established during the Action FP1001 (2012)
Romania	79	79	80	79% based on management planning data 80% based on NFI data	Yes. New variables considered in assessing FAWS in NFI.
Portugal	53	66	62	Accessibility and recreation not considered	Yes. Inclusion of new restrictions in the estimation
Spain	82	80	70	Accessibility and recreation not considered	Yes. Inclusion of new restrictions in the estimation
Sweden	72	71	70	Productivity (1m ³ /ha) is included as a legal and economic restriction	Yes. Inclusion of new restrictions in the estimation
Switzerland	97	96	96	Social restrictions not considered. Only protected areas are excluded from FAWS	Yes. Definition established

affected) international reporting. Figures of FAWS provided in the international reporting seem to be greater than the ones obtained applying the harmonized definition. The reason for this lower value when considering the reference definition is in most of the countries the consideration of additional restrictions and therefore the exclusion of greater forest area. Variables having a significant impact on wood supply were analysed and clarified for those countries able to work towards data harmonization at European level (NFIs). However, further harmonization efforts are needed as it has been evidenced (Table 4), particularly regarding social and economic restrictions.

An alternative approach for accounting for “significant impacts on wood supply” when estimating FAWS could be achieved based on the proportion of wood resources utilised. For instance, in Lithuania it has been observed that different groups of FNAWS show different intensity of wood use (gross increment divided by annual fellings) (OECD, 2013) from 0% up to 20%. In total, the wood used from FNAWS is three times less when compared to FAWS. This example shows, that “significant impacts of wood supply” or intensity of wood use can be different not only for different countries, but also for different forest categories within the same country. Until now, not all NFIs are able to provide appropriate data. Due to further NFI developments, it can be assumed that the number of NFIs able to provide such data will increase.

The proposed definition is of major importance for any kind of modelling of the European Forest and therefore for decision makers and forest related policies, particularly in light of future scenario within the EU which highlights a deficit in wood supply (Scarascia-Mugnozza and Pisanelli, 2008). Considering the relevance of FAWS estimation to set targets for biomass and energy, for global change mitigation and on wood resources strategies, further analysis should be done undertaken to ensure the adoption of a harmonized definition for FAWS.

5. Conclusions and recommendations

Currently estimates of FAWS are not easily comparable but new international goals, targets and instruments will require robust, up-to-date and harmonized data. A reference definition for FAWS has been proposed in this paper under the framework of the COST Action FP1001, with the aim of reducing ambiguity in the existing national definitions and increasing the comparability of estimates made available for international reporting. The proposed reference definition defines principles and determines the different restrictions limiting wood supply.

Notwithstanding the proposed reference definition, there still remains a need for further analysis to investigate the relevance of different restrictions and their thresholds. Case studies are required to determine the thresholds for defining the nature and aim of silvicultural

interventions, and thus, the inclusion or exclusion of forest areas such as ‘protective forest’ and ‘recreational areas’ as FAWS. Nowadays it is necessary for countries to specify their own thresholds as they may vary depending on national peculiarities. However, for transparency's sake, the restrictions and thresholds should be recorded when reporting. An alternative approach to the proposed reference definition, through the evaluation of wood use (gross increment divided by annual fellings), has been proposed which could avoid some of the current harmonization problems as the “significant impact of wood supply” would be quantified.

It is worth noting that the ‘protected area’ restriction can be reported for most countries and would provide the most consistent information currently available. However, the protection classes classified as FAWS/FNAWS by individual countries vary greatly and should be declared when reporting. A possible solution for this problem could build on the pan-European classification of protected areas (MCPFE, 2003), which focuses on the level of intervention.

The refinement of the FAWS/FNAWS definition does not automatically guarantee improvement in the data reported. The new definition has to be incorporated into international forest monitoring processes and further guidance has to be developed in conjunction with international experts.

Finally, it is important to highlight that greater emphasis should be put on the interpretation of data and their use by decision/policy makers. A closer link between the end users and data providers to discuss the reported values will help ensure the data are correctly interpreted.

Contributions of the co-authors

Iciar Alberdi: Coordination, questionnaire design, national estimation of FAWS, data analysis, results analysis and elaboration of the paper.

Roman Michalak: results analysis and writing of manuscript.

Christoph Fischer: FP1001 questionnaire design, national estimation of FAWS, data analysis and writing of manuscript.

Patrizia Gasparini: FP1001 questionnaire design, national estimation of FAWS, results analysis and writing of manuscript.

Urs-Beat Brändli: FP1001 questionnaire design, results analysis and writing of manuscript.

Stein Michael Tomter: national estimation of FAWS, ToS of SFM questionnaire design and writing of manuscript.

Andrius Kuliesis: national estimation of FAWS, ToS of SFM questionnaire design, data analysis and writing of manuscript.

Arnor Snorrason: national estimation of FAWS, results analysis and writing of manuscript.

John Redmond: national estimation of FAWS, writing of manuscript and edition.

Adrian Lanz: FP1001 questionnaire design and web application.

Laura Hernández: data analysis and writing of manuscript.

Beatriz Vidondo: data analysis.

Nickola Stoyanov: writing of manuscript.

Maria Stoyanova: writing of manuscript.

Martin Vestman: national estimation of FAWS and writing of manuscript.

Susana Barreiro: national estimation of FAWS and writing of manuscript.

Gheorghe Marin: national estimation of FAWS and writing of manuscript.

Isabel Cañellas: writing of manuscript.

Claude Vidal: results analysis and writing of manuscript.

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