

Review

Contribution of social science to large scale biodiversity conservation: A review of research about the Natura 2000 network



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ABSTRACT

Successful conservation needs to be informed by social science because it is closely linked to socio-economic processes and human behaviour. Limited knowledge about ecosystems' interactions with these processes currently undermines conservation efforts. This review provides a comprehensive synthesis of social science concerning the world's largest multinationally-coordinated conservation infrastructure: the European Ecological Network - 'Natura 2000'. Based on a review of 149 publications, we analyse and discuss the main findings and outline key social-science research gaps with regard to the Natura 2000 network. The review shows that human dimension of the Natura 2000 network is complex and varies among EU Member States. In general, low level and quality of public participation in implementation of the Natura 2000 network and its management, negative public perceptions of the network, lack of flexibility of responsible authorities and insufficient consideration of the local context pose the greatest challenges to the network's functioning. Important but hitherto little studied research topics include: evaluation of participation; effects of education on potential to raise public awareness; effects of potential financing mechanisms for compensating private land-owners; economic studies on cost-effectiveness; and benefits from conservation and ecosystem services. These knowledge gaps will need to be filled for the Natura 2000 network to reach its goals.

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Contents

1.	Introduction	111
2.	Methods	111
3.	Results	113
3.1.	Focus of the publications	113
3.2.	Synthesis of the main findings	113
3.2.1.	Conservation conflicts and implementation challenges/solutions	113
3.2.2.	Management	116
3.2.3.	Perceptions, attitudes and values.	116
3.2.4.	Valuation and economics	116
3.2.5.	Legal issues	117
3.2.6.	Governance	117
3.2.7.	Policy integration.	117
3.2.8.	Conservation priority setting	117
3.2.9.	Participation evaluation.	118
4.	Discussion	118
4.1.	Main findings and their implications	118

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4.2. Research gaps	119
Acknowledgements	120
Appendix A. Supplementary data	120
References	120

1. Introduction

Conservation science is characterised by a “tight coupling of social and natural systems” (Kareiva and Marvier, 2012). Successful conservation is not solely contingent on ecological knowledge, but should also incorporate human behaviour and the resulting social processes which eventually influence the status of biodiversity (Ban et al., 2013; Fox et al., 2006). It is vital for conservation professionals to understand the factors shaping human–environment interactions, particularly human choices concerning the use or conservation of natural resources (Mascia et al., 2003). For example, the human-induced global water crisis endangers not only human societies, but also affects freshwater biodiversity (Vörösmarty et al., 2010). Anthropogenic global climate change is not only posing challenges to humans, but is also perceived as one of the most serious threats to the planet’s biodiversity (Malcolm et al., 2006). Moreover, it has become obvious that conservation measures cannot be fully successful if poverty issues are not tackled (Adams et al., 2004). Therefore successful conservation requires recognition and understanding of the value of social science research, i.e. research that uses conceptual and theoretical underpinnings of social sciences, such as sociology, human geography, social policy, social psychology, political sciences, economy, public communication and management to investigate human behaviour and associated social processes (Bryman and Teevan, 2005).

However, there is an increasingly recognised gap in understanding and tradition of co-operation between natural and social scientists, and particularly a lack of appreciation of social science knowledge in practical operation of conservation policy (Liu et al., 2007). This problem needs to be addressed if we want to produce knowledge that truly contributes to solving today’s conservation challenges (Fox et al., 2006; Nyhus et al., 2002). Comprehensive syntheses of social science research concerning major conservation initiatives may contribute to building that knowledge.

One key conservation action worldwide is the development of large-scale networks of protected areas (Rodrigues et al., 2004). In spite of the fact that over 200,000 protected areas cover ~14% of the world’s land area (Deguignet et al., 2014), there are very few coordinated networks of protected areas aiming at continental-scale conservation. Examples of such networks stretching across national borders include the Yellowstone-to-Yukon Conservation Initiative in North America and the European Ecological Network – ‘Natura 2000’. The latter is the world’s largest multinational coordinated conservation infrastructure.

As the centrepiece of the European Union’s (EU) biodiversity conservation policy, the Natura 2000 network was created based on the Article 3 of the EU’s Habitats Directive (CEC, 1992). It aims at protecting habitats and species of EU interest, listed both in the Habitats Directive and Birds Directive (CEC, 1979, 1992). The Natura 2000 network plays a key role in protection of biodiversity in the EU territory by “assuring the long-term survival of Europe’s most valuable and threatened species and habitats” (EC, 2015a). The network consists of Special Protection Areas – SPA (for protecting species included in Birds Directive), Special Areas of Conservation – SAC (species and habitats included in Habitats Directive), and also includes marine environments (EC, 2015a). Natura 2000 has been implemented gradually, starting in 1992 in the 12 EU countries, followed by other countries joining the European Union afterwards. This initiative is considered critical for the implementation of international conservation policies such as the Convention on Biological Diversity (UN, 1992) and the European Strategy for Biological Diversity

(EC, 2011). The Natura 2000 network considerably differs from previous conservation systems in Europe as it goes beyond a direct ban on damaging plants or killing animals and focuses on socially sustainable conservation harmonising the maintenance of species and habitats with economic, social and cultural human needs (Grodzińska-Jurczak, 2008). Because of that the meaningful involvement of affected stakeholders is seen as necessary for the network’s success (EC, 2000).

The entire implementation process, starting from the selection of the protected sites till development of management plans, met opposition from various stakeholder groups in almost all EU Member States (Alphandéry and Fortier, 2001; Hiedanpää, 2002; Krott et al., 2000; Pietrzyk-Kaszyńska et al., 2012; Visser et al., 2007). The problems in implementation called for a proper assessment and monitoring of the network, and eventually led to the development of more effective implementation recommendations (Bouwma et al., 2008; Kati et al., 2015). In 2015, the European Commission initiated a process of fitness check on the implementation of the Birds and Habitats Directives. The fitness check aims at scrutinising the effectiveness, efficiency, relevance and coherence (EC, 2015b) of all stages of the network implementation, from the designation through inventory and monitoring to the development of management plans for particular sites.

Considering its importance for European nature conservation Natura 2000 has also been the subject of an increasing research interest, particularly from conservation scientists (Popescu et al., 2014). To achieve a good functionality of the network, there is a need for knowledge not only on the ecological conservation and management issues relevant to the Natura 2000 (e.g. status of species and habitats, ways of managing the sites), but also on key social, economic, political and managerial realities potentially influencing its effectiveness. In a recent review of published research on Natura 2000, Popescu et al. (2014) concluded that ecological research prevails, while social, economic and policy research on the network is underrepresented. Still, there is a non-negligible body of research focusing on the social aspects of the Natura 2000. However, perhaps as a consequence of its broad scope, there have been so far no attempts to comprehensively review this research. In this paper, we present a review of the published scientific literature focusing on the social aspects of the Natura 2000 network, expanding Popescu’s et al. (2014) work by analysing in depth the findings of the existing social science studies. The aims are to (1) synthesise the existing social scientific knowledge on Natura 2000 and identify future research needs, and (2) inform conservation professionals and other relevant actors about the broad spectrum of challenges and solutions relevant to the implementation and functioning of the Natura 2000 network.

2. Methods

We performed an in-depth review and analyses of published English-language scientific papers applying a social science perspective in conservation research focused on Natura 2000. We are aware of the fact that some social aspects of Natura 2000 may be addressed in the “grey literature” or local manuscripts or reports. However, here we focused on the peer-reviewed literature only because (1) we wanted to concentrate on scientific knowledge, with a reliable level of scientific rigour, (2) it would have been logistically impossible to directly cover the diversity of “grey literature” characterised by a multiplicity of languages, and (3) the peer-reviewed literature builds to a large extent on analyses of various types of non-scientific texts (reports, legal texts, articles, etc.) published in different languages, and hence our approach

does indirectly capture substantial parts of the information contained in these publications.

We collected the data through desk research. The main unit of our analysis was an individual article. We applied a mixed-mode social science research methodology (qualitative and quantitative) that allowed for a broader perspective of gathering and analysing of the data. We used the Web of Science™ Core Collection database for searching the literature. We searched for the phrase “Natura 2000” in the “topic” field of the database for the period 1998–2014. From the initial set of publications, we only retained studies that were either primary original research or reviews; thus, we removed publications categorised as correspondences, letters, responses, commentaries, policy perspectives, etc. Conference proceedings were only included if published in a peer-reviewed journal. We also removed publications in other languages than English, even if they had an English abstract. After this selection we ended up with 664 publications (as of January 1st, 2015).

We performed an initial scanning of selected publications to retain only articles that addressed social science or included a social analysis component (e.g. inter, multi or transdisciplinary studies combining social sciences with other disciplines). After that preliminarily scanning, 248 publications were classified as belonging to the social sciences or as having a social-science component. A review of the ecological literature about Natura 2000 will be published elsewhere (Orlikowska et al. unpublished results). Out of the 248 publications retained for the present review, we further removed 46 after in-depth examination, either because they were not research/review papers or because they did not address Natura 2000. For example, if a paper had “Natura 2000” merely in the abstract but did not focus at all on any aspect of Natura 2000, we removed it from the analysis. We removed another 39 publications because in-depth examination revealed that they did not include any social-science analysis. Finally, we removed 14 publications due to unavailability of the full-text versions. Thus, 149 publications were left for in-depth analysis, 112 classified as social science and 37 including some social-science analysis. The [Results](#) section below is based exclusively on these publications. However, in the [Discussion](#) section we also refer to some relevant studies not identified by our search, e.g. studies published after the closing date of our literature search. Note that 91 of the 149 publications retained for the present study were included in the recent review by [Popescu et al. \(2014\)](#). Our review includes 58 papers not analysed by these authors, while 29 of the papers they included were not retained for the present study. These differences are most likely due to the different inclusion criteria used in the two studies.

The first step of the analysis consisted in distinguishing eleven core categories of papers ([Table 1](#)) based on their main focus, identified through reading the title and abstract of each publication. We then used a qualitative content analysis method ([Bryman and Teevan, 2005](#)) for analysing all the papers. We utilised an open coding approach without pre-defined codes. Thus, the codes emerged in the course of analysis and involved identification of the most important issues and the key findings of the papers. We analysed each of the eleven categories of papers separately using specific codes for each particular category of papers. Because some of the initial categories were of a relatively broad scope, the analysis led to the identification of a set of sub-categories within five of the main categories of papers (see [Table 1](#) for explanation). In the next step of the analysis, we used memos ([Glaser and Strauss, 2008](#)) for summing up information on the identified issues and key findings. Using the memos and building on the issues identified in them, we created summaries of the results by categories and discussed their determinants in the context of the main socio-economic findings for each category (see [Results](#) section). At the same time, we created a short summary of each paper (see online Appendix). We also recorded the country (or countries) investigated by each of the papers. Finally, we scrutinised the scope of all papers (based on their categories and sub-categories) to identify the most commonly addressed topics and the main research gaps.

Table 1
Categories and sub-categories used to structure the review process.

Category	Contents of the papers	Sub-categories
Conservation conflicts	Includes studies that analyse conservation conflicts, e.g. actual or potential conflicts between N2000 site protection and resource use, human well-being or tourism, potential problems in industrial/infrastructure development within or in the vicinity of N2000 sites, threats to N2000.	–Conservation vs. use –Conservation vs. development –Threats to N2000 sites –Combining tourism and conservation –Policy ^a
Implementation challenges and solutions	Includes studies that address different challenges faced during at least one stage of the N2000 policy implementation (including site designation, development of management plans, monitoring, etc.), and/or presents potential solutions to these challenges.	
Management	Includes assessment of the human dimension of management practices, adaptive measures or need for appropriate management plans to maintain species in favourable status, methodological studies on the development of management plans for N2000 sites or planning conservation action, studies proposing tools, approaches and frameworks for development of management plans and conservation strategies, etc.	–Tools, methods, approaches –Management and CC –Management evaluation –N2000 impact on management –Restoration management –Need for management
Perceptions, attitudes and values	Includes studies that investigates attitudes towards and perceptions of various aspects of the N2000 network, attitudes towards particular N2000 sites or their management, people's awareness of the N2000, etc.	–Local attitudes –Perceptions of management –Recreation and tourism –Other (see Online Appendix)
Valuation and economics	Includes studies that investigate costs or benefits of the N2000 establishment, management measures or restrictions, effectiveness of N2000 conservation funding, valuation (both use and non-use values) of the N2000 site, incentive mechanisms, etc.	–Preferences and WTP –Benefits from N2000 –Cost-effectiveness –Costs of N2000 –Incentives
Legal issues	Includes studies on legal aspects of N2000, e.g. analysis of legal acts and their consequences, or of some specific topic related to N2000 in relation to legal requirements.	–National level enforcement –Legislation effectiveness –CC in N2000 legislation –ES in N2000 legislation
Governance	Includes studies on different aspects of governance related to N2000, e.g. governance shifts due to implementation of the N2000, changes in possibilities of different actors to influence governance.	n/a
Policy integration	Includes studies that analyse N2000 policies that have been formulated and used during the designation and management processes, and potential problems connected with their relation to policies belonging to other sectors, e.g. potential overlaps, possibilities or barriers for integration of different policies.	n/a
Conservation priority setting	Includes studies that focus on determining conservation priorities or utilise systematic conservation planning with regard to N2000 which include socio-economic indices or criteria.	n/a
Participation evaluation	Includes studies that focus on evaluation of participatory processes in	n/a

(continued on next page)

Table 1 (continued)

Category	Contents of the papers	Sub-categories
	relation to N2000 implementation and operation, e.g. participatory aspects of the designation processes of particular sites or the whole network, or related to the N2000 network.	
Other	Studies that do not fit in any of the categories above.	See Online Appendix

Note: CC = climate change; ES = ecosystem services; N2000 = Natura 2000; WTP = willingness to pay.

n/a – not applicable; small category including few papers, no need to have sub-categories.

^a The category “Implementation challenges and solutions” is a broad category including studies that analyse challenges and solutions from very different perspectives and at different stages of Natura 2000 implementation. Because of that inherent diversity at the level of individual papers, it was not possible to define distinct sub-categories that would include meaningful numbers of papers.

We are aware that the division into particular categories and sub-categories is to some extent subjective and arbitrary, as many papers address more than one issue and thus one paper could theoretically be included into two or more categories simultaneously. However, to allow a structured analysis we needed a clear division into categories. Thus, in cases where a particular paper fitted more than one category, we assigned the paper to the category which represented the main focus of the paper.

Even though some of the papers had a wider scope than Natura 2000, in the present review we only consider the information concerning this network. Thus, if a paper was about different kinds of protected areas including Natura 2000 sites, we only considered the contents which specifically concerned Natura 2000.

3. Results

3.1. Focus of the publications

Most of the publications belonged to the category of ‘Conservation conflicts’ (23 publications), ‘Implementation challenges and solutions’ (21), ‘Management’ (20), ‘Perceptions, attitudes and values’ (17), ‘Valuation and economics’ (16), ‘Legal issues’ (11), ‘Governance’ (8), ‘Policy integration’ (5), ‘Conservation priority setting’ (4), and ‘Participation evaluation’ (4). The remaining 20 publications were classified as ‘Others’ (Fig. 1).

The ‘Conservation conflicts’ category focused mainly on local land use or infrastructure development in potential conflict with conservation in particular locations (Fig. 2). Many papers focused on particular challenges faced by Natura 2000 and possible solutions (papers from

‘Implementation challenges and solutions’ category) or tools and methods for practical work with Natura 2000 (11 out of 20 papers in the ‘Management’ category) – both groups studying the factors influencing the practical implementation of the network. Within the category ‘Perceptions, attitudes and values’, the largest topic was the attitudes of local communities (10 out of 17 studies) (Fig. 2). Valuation/economic studies in most cases investigated preferences and willingness to pay for Natura 2000 conservation or management (5 out of 16 studies) or cost-effectiveness of conservation (5 out of 16 studies).

Twenty-five publications presented studies encompassing the entire EU. In terms of particular countries, Greece had the highest level of representation in the publications, followed by the Netherlands, UK, Germany, Poland, Romania and Italy (Fig. 3). In general, the EU-15 countries (i.e. countries that had joined the EU prior to 1st May 2004) had more (altogether 117, mean 11 per country) publications than the countries that joined the EU in and after 2004 (altogether 40, mean 4). Important exceptions were Belgium and Sweden, two EU-15 countries with only one publication each, as well as Poland and Romania, two late-accession countries with relatively large numbers of publications (Fig. 3). At the level of the whole EU, most of the publications concerned either legal issues (4 papers), followed by valuation, governance and implementation challenges and solution studies (3 papers in each of these categories). Most publications about management were conducted in Italy (5 papers), followed by Greece and the Netherlands (4 papers each), while Romanian studies focused on conservation conflicts (6 papers) (Fig. 4).

3.2. Synthesis of the main findings

In this section, we synthesise the findings of the reviewed articles for the different main categories (Table 1). We do not include the category ‘Other’ because it represents studies that lack common findings. A short summary of all the reviewed publications (including those in category ‘Others’) is included in the online Appendix.

3.2.1. Conservation conflicts and implementation challenges/solutions

‘Conservation conflicts’ and ‘Implementation challenges and solutions’ categories are related and therefore we address them together.

The potential conflicts in implementation and functioning of the network were those between conservation under Natura 2000 and different kinds of land and water use, such as forestry (Hiedanpää, 2002; Pecurul-Botines et al., 2014), farming (Gonzales et al., 2009; Oana, 2006; Visser et al., 2007), fishing (Pedersen et al., 2009; Zaharia et al., 2014; Zaharia et al., 2012), ship navigation (Freitag et al., 2008), as well as industry and infrastructure development (Andrulewicz et al., 2010; Bielecka and Różyński, 2014; Wszolek et al., 2014). Some studies

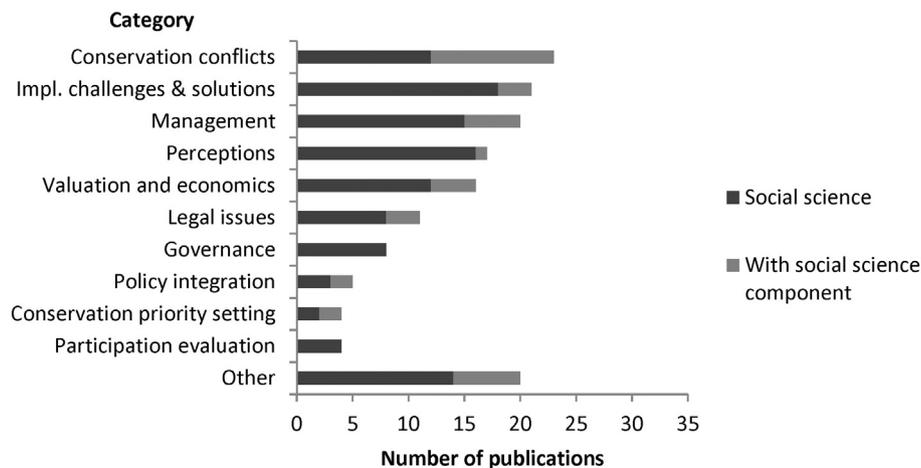


Fig. 1. Number of publications belonging to the main categories.

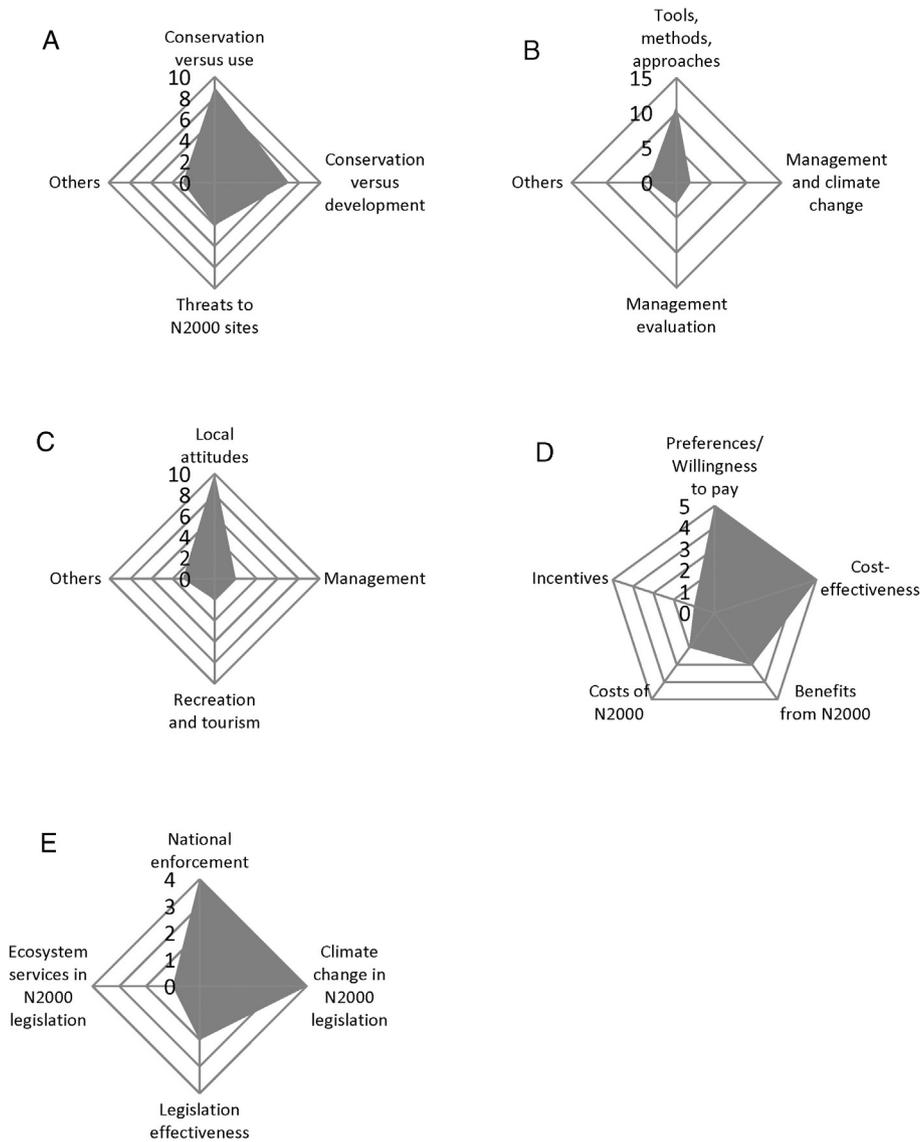


Fig. 2. Number of articles belonging to the different sub-categories within main categories. Only five categories are included, as other categories were not divided into sub-categories (for explanation see Table 1). A: conservation conflicts; B: management; C: perceptions attitudes and values; D: valuation and economics; E: legal issues.

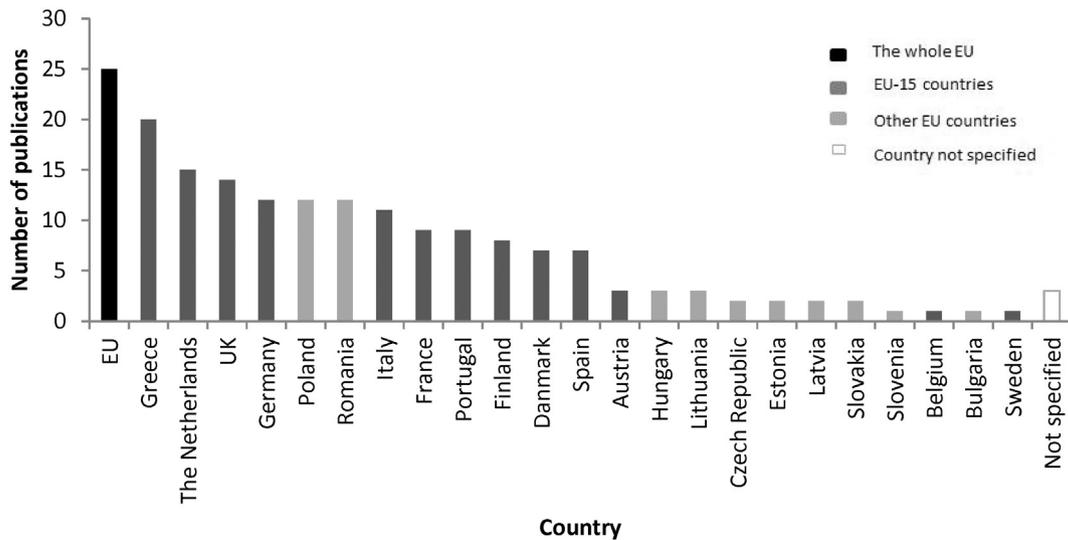


Fig. 3. Number of articles presenting research pertaining to individual EU countries. Note that in some articles more than one country was included, and thus one article could be listed under more than one country. Both social-science articles and articles with a social-science component are included.

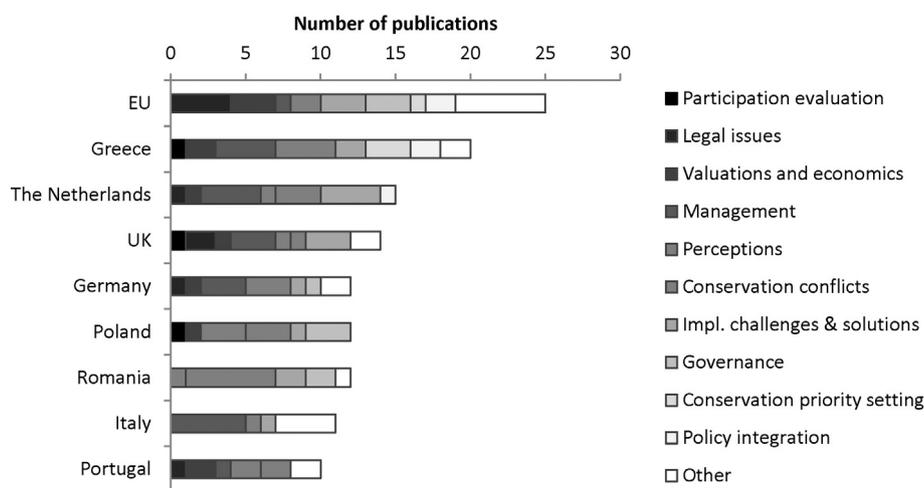


Fig. 4. Number of publications in each category for individual countries with ≥ 10 papers. Both social-science articles and articles with a social-science component are included.

in the 'Conservation conflicts' category investigated the impacts of different anthropogenic activities on Natura 2000 areas (Muntean et al., 2013; Pîrvu and Petrovici, 2013), with a particular focus on agro-tourism (Ciapala et al., 2014; de Noronha Vaz et al., 2012). According to Hiedanpää (2002), "the administrative environmental actions disturb localities in intended good ways, but also in many unintended and surprising ways" which can be perceived by local people as harmful and immoral. However, whether the conflict will arise depends on the local institutional context (Pecurul-Botines et al., 2014).

As key approaches for addressing existing conflicts, mitigating threats, and improving implementation and functioning of the network, different authors suggested cooperation and improved communication with the resource users, as well as development of management plans for each site using participatory approaches (Pedersen et al., 2009; Pîrvu and Petrovici, 2013; Visser et al., 2007; Zaharia et al., 2014). Indeed, increased social support of formal rules was considered a key to successful implementation (Beunen et al., 2013). Such cooperation can elicit valuable local knowledge helpful to conservation (Pedersen et al., 2009), but requires meaningful involvement of a wide spectrum of stakeholders (Ferranti et al., 2010). Hiedanpää (2005) described such involvement in terms of a "transactive approach", i.e. a "participatory, discursive, engagingly organised, sensitively operated, and decisively powerful approach". Participatory approaches should operate within and be sensitive to the local and regional economic context (Hiedanpää, 2002), address conflicting issues across different sectors (Andrulewicz et al., 2010) and enable land users to understand the benefits from particular Natura 2000 sites (Oana, 2006). This is particularly important with regard to farming: to avoid the ongoing in the EU land abandonment, there is a need to win "the minds and hearts of future farmers" (Visser et al., 2007). The latter need to be convinced about the benefits of conservation (Kamal and Grodzinska-Jurczak, 2014; Prazan et al., 2005) as they may fear potential limitations imposed by Natura 2000, including compromises linked to their place identity (Welch-Devine, 2012). This can only be accomplished when both sides (conservation and food production) acknowledge the importance of each other's priorities (Visser et al., 2007). Also, as conservation may imply significant costs for the landowners, there may be a need for financial instruments such as public funding or tax reductions (Rojas-Briales, 2000). The need for sufficient funding was underlined in several studies (Ferranti et al., 2010; Hochkirch et al., 2013; Iojă et al., 2010), for example as regards financial compensation schemes for landowners (Stancioiu et al., 2010) and activities that would increase general conservation awareness (Hochkirch et al., 2013). Similarly, Ciapala et al. (2014) suggested that tourism and recreation are "inherent element of human influence on biodiverse areas", and that such activities need to be considered when

planning for and managing Natura 2000 sites. To address that, Parolo et al. (2009) proposed an optimisation model for allocating tourism infrastructure.

Regarding the key challenges of the Natura 2000 implementation, the studies identified problems pertaining to legitimacy of the implementation process (Alphandéry and Fortier, 2001), low capacity of the state in implementation (Apostolopoulou and Pantis, 2009) or weaknesses in the scientific work (Alphandéry and Fortier, 2001). A lack of proper participatory approaches implemented at the local level (Alphandéry and Fortier, 2001; Apostolopoulou and Pantis, 2009; Iojă et al., 2010) was also frequently mentioned. Even in cases where participation took place, emphasis on legal procedures could reduce the quality of deliberation (Beunen et al., 2013). On the other hand, some studies underlined that EU accession and associated implementation of EU policies provided new opportunities for participation of local actors and better cooperation among governmental institutions rarely used so far, especially in post communistic countries (Prazan et al., 2005).

Lack of clear implementation goals and discrepancy between stated and actual goals can also compromise the national-level implementation of the Habitats Directive (Apostolopoulou and Pantis, 2009). In addition, superimposing the Natura 2000 sites onto existing (e.g. national) systems of protected areas may lead to duplication of administration and legislation, as well as overly complex protection systems (Papageorgiou and Vogiatzakis, 2006). For example, in Romania the Natura 2000 network overlapped at ~96% with existing protected areas, with some sites having up to three different protection forms (Iojă et al., 2010).

Alphandéry and Fortier (2010) emphasised that the implementation of the Habitats Directive is a non-linear, at times chaotic process that occurs at different scales from the local to the European level. In relation to this complex process, some authors highlighted the crucial role of local actors (Borrass, 2014). Ferranti et al. (2010) suggested education and training of local authorities to improve the practical implementation and Louette et al. (2011) proposed the development of regional conservation objectives as a means to bridge the gap between local and national interests. Several authors underlined the need for better cooperation among national-level authorities (Prazan et al., 2005) and the importance of inter-sectoral cooperation (Papageorgiou and Vogiatzakis, 2006; Sarvasova et al., 2013). Alphandéry and Fortier (2010) argued that proliferation of procedures and provisionality in implementation are natural elements of the Natura 2000 implementation, and that they do not necessarily imply inefficiency of the government. Beunen et al. (2013) underlined the need to take into account the particular context and interests in the implementation process. Beunen and van Assche (2013) cautioned against the "blindness of legalism" and

suggested flexible local planning as the best means of enabling space for deliberation of different interests when implementing Natura 2000. “Once we recognize that formal rules can never be sustained without public support and we understand that public narrative determines their success, we can no longer ignore this dimension of nature conservation in research and practice” (Beunen et al., 2013), as “the battle for biodiversity will be won or lost at local levels” (Bryan, 2012).

3.2.2. Management

A large proportion of the papers in this category (11 out of 20) proposed or examined different methods to facilitate the planning of management activities in Natura 2000 sites and support the development of management plans for these sites. These studies most commonly proposed participatory approaches to knowledge production, scenario development and planning of management activities (Bots et al., 2011; Gil et al., 2011; Graziano et al., 2008; Oikonomou et al., 2011). For example, Ernoul et al. (2011) and Teofili and Battisti (2011) proposed the use of ‘Open Standards for the Practice of Conservation’, adapted to the local specifics of each site, that promote participatory processes for adaptive management. Other approaches took into account the human dimension by using indices of human activities in management planning (Cortina and Boggia, 2014) or adopting an ecosystem services perspective (Scolozzi et al., 2014). The remaining studies were of a very diverse character. They focused, for example, on evaluating the management (Ganatsas et al., 2013; Morris et al., 2014; Winter et al., 2014) or implications of particular policies for the Natura 2000 network (Fock, 2011).

A number of recommendations have been made for the design of participatory process in management planning. For example, Bots et al. (2011) proposed that the process should be set up to favour openness, protection of the actors’ core values, use of relevant knowledge and possibility to acknowledge uncertainties; Oikonomou et al. (2011) emphasised the necessity of considering the social value judgements of different actors; and Gil et al. (2011) underlined the need for participation and co-responsibility of all relevant stakeholders. Also, Malatinszky et al. (2014) emphasised the necessity to set a priority order of conservation aims at an early stage of management planning, based both on science and the needs and interests of relevant stakeholders. The issues identified in this set of papers included the lack of time, resources and qualified facilitators that could serve the participatory process (Ernoul et al., 2011) and lack of flexibility of authorities due to strict regulations (Malatinszky et al., 2014). According to Malatinszky et al. (2014), “management planning should be based on current, exact, relevant ecological and social circumstances, and historical land uses. Therefore, this process cannot be simplified into following a planning scheme”. It was also underlined that, to improve effectiveness of management schemes, legal provisions concerning management need to be matched with local capacity (Morris et al., 2014).

According to Cortina and Boggia (2014), a multi-criteria approach that incorporates both the ecological and the human dimension is particularly useful for Natura 2000 management planning, as it enables addressing a multidimensional decision process and the complex nature of biodiversity itself. Also Soane et al. (2012) underlined the multidimensional and dynamic nature of many Natura 2000 sites. These authors applied resilience theory to describe the complex socio-ecological systems of managed alpine grasslands. They proposed that this theory can support adaptive management of Natura 2000 sites, as it “offers useful insights into resource management and in particular for nature conservation interest sites, by focusing more on dynamics than on an optimal state of species assemblages”.

3.2.3. Perceptions, attitudes and values

Most of the publications in this category (10 out of 17) aimed at investigating the attitudes of various (predominantly local) stakeholders towards Natura 2000. They revealed both positive and negative attitudes towards the network. It was generally considered as a good tool for conservation (Dimitrakopoulos et al., 2010; Grodzinska-Jurczak

and Cent, 2011; Mouro and Castro, 2009; Pietrzyk-Kaszyńska et al., 2012; Sumares and Fidelis, 2009), but also as an impediment to economic sustainability, whereby it was often perceived as being associated with a ban on development at practically all levels (from local to regional) (Grodzinska-Jurczak and Cent, 2011; Sumares and Fidelis, 2009). Moreover, in some cases, the perceived “dictatorship-style”, top-down implementation contributed to a low level of trust towards the network and associated authorities (Sumares and Fidelis, 2009). For example, many landowners in Poland viewed top-down management of private land as questioning their capability and rights to manage the land. As a consequence, these landowners tended to distrust the authorities (Kamal and Grodzinska-Jurczak, 2014). A study from Greece (Andrea et al., 2013) showed low satisfaction of the local people with the work of local authorities implementing the network. This case pointed to staff deficiencies and irregular funding as main obstacles for effective management. On the contrary, a study from another Greek region (Dimitrakopoulos et al., 2010) showed greater acceptance towards local implementing actors, but high distrust towards higher-level governmental actors, indicating that the local perceptions may be context dependent. In a study from Latvia (Pavasars, 2013) the problem of mistrust towards authorities was described in terms of existence of “parallel realities”, i.e. that of “official environmentalism” and that of the everyday life of people in the countryside.

Insufficient communication (Grodzinska-Jurczak and Cent, 2011; Tonder and Jurvelius, 2004) and weak, if any, traditions of participation (Grodzinska-Jurczak and Cent, 2011; Sumares and Fidelis, 2009) were underlined as factors contributing to low trust. Well organised and more meaningful participation, stronger collaboration with local stakeholders (Dimitrakopoulos et al., 2010; Kamal and Grodzinska-Jurczak, 2014) and better cooperation between administrative bodies (Andrea et al., 2013) were proposed as means to improve acceptance towards Natura 2000. The need to increase awareness towards N2000 through proper information campaigns was also underlined (Kafyri et al., 2012; Marmureanu and Geamana, 2012).

Numerous individual-level factors were found to influence attitudes towards conservation in general and Natura 2000 in particular. These were, for example, education, the fact of moving to the area affected by Natura 2000 designation in adulthood, ownership of a business (Pietrzyk-Kaszyńska et al., 2012), vested interests, institutional trust, place identification (Mouro and Castro, 2009), socio-economic position, culture and social backgrounds (Tonder and Jurvelius, 2004), as well as the degree of satisfaction with the recreational experience (Torbidoni, 2011).

3.2.4. Valuation and economics

Most publications in this category encompassed studies about people’s preferences and their willingness to pay (WTP) for particular protection measures or management plans in Natura 2000 sites (Grammatikopoulou and Olsen, 2013; Hoyos et al., 2012; Jones et al., 2011; Li et al., 2004; Rekola et al., 2000; Strange et al., 2007). Moreover, some studies investigated the costs of particular measures and activities in the sites (Jacobsen et al., 2013; Lee, 2001), services and benefits from Natura 2000 (Cruz et al., 2011) and cost-effectiveness or efficiency of Natura 2000 (Jantke et al., 2010; Wätzold et al., 2010; Wätzold and Schwerdtner, 2005), particularly with regard to conservation funding (Lung et al., 2014; Santana et al., 2014).

Even though people often had positive attitudes towards proposed conservation measures (Grammatikopoulou and Olsen, 2013; Pouta et al., 2000), their WTP depended on different factors, such as the ability of the conservation programme to take into account the rights of landowners, the respondents’ opinion about the importance of preserving species and biotopes (Pouta et al., 2000), their level of knowledge about species to be protected (Strange et al., 2007), and the level of trust towards particular options (Jones et al., 2011). Also socio-demographics were important predictors of the WTP, as young, high-income and urban populations show stronger support for conservation (Pouta

et al., 2000). Moreover, respondents with lexicographic preferences for nature rights were willing to pay much more for conservation than those with preferences for property rights (Rekola et al., 2000).

Relatively few studies (3 out of 16) focused on the benefits from Natura 2000. Cruz et al. (2011) outlined ecosystem services provided by a Special Protected Area in the Azores Islands, such as those related to water provision, quality and regulation, and also underlined the role of Natura 2000 in job provision. Other studies showed that the non-use values of the protected areas can exceed the use values (Hoyos et al., 2012; Strange et al., 2007).

Studies that focused on cost-effectiveness of Natura 2000's implementation and functioning were scarce (Wätzold and Schwerdtner, 2005). Wätzold et al. (2010) pointed to lack of long-term funding, wrong allocation of funds between different tasks when designing and implementing management plans, and costly EU requirements on monitoring as key problems. Lung et al. (2014) concluded that the distribution of EU biodiversity funding was generally well aligned with the existing Natura 2000 network, but not with the future needs linked to climate change. Jantke et al. (2010) showed that the current Natura 2000 network does not cover well all endangered wetland vertebrate species. They estimated that additional 3 million ha of protected areas would be required to achieve coverage of all important species, at an estimated cost of 107 million Euros per year.

We identified only one study on economic incentives supporting Natura 2000 implementation (Anthon et al., 2010). The paper presented theoretical justification for using contracts when implementing the network in forest areas and discussed different mechanism of payment used in Natura 2000 contracts.

3.2.5. Legal issues

Publications about legal issues mostly investigated national-level enforcement of Natura 2000 legislation, particularly with regard to Environmental Impact Assessment (EIA). The general view was that Natura 2000 legislation was still not fully incorporated into national legislations (Vaiškūnaitė et al., 2012) although clear improvements could be observed (Christensen, 2006). It was proposed that specific socio-legal conditions must be fulfilled for a better implementation and functioning of the Natura 2000 legislation, such as e.g. capacity of the public interest groups and their access to national courts or the way in which European provisions are interpreted by national courts (Slepcevic, 2009). A study by Marandi et al. (2014) suggested that protection should be actually commenced as soon as a specific area is proposed for inclusion in the Natura 2000 network.

Other studies investigated the effectiveness of the Natura 2000 legislation. For example, Leone and Lovreglio (2004) described it as one of the most important building blocks contributing to conservation, and Mallard and François (2013) concluded that the Natura 2000 network is the most effective instrument for conservation in relation to road planning in France. However, they criticised the fact that the road construction permits can be issued for “imperative reason of major public interest”, which limits the power of the Natura 2000 legal requirements in practice. Weaknesses of the national Natura 2000 legislation could be also observed in Lithuanian road planning, where EIA procedures and principles did not comply with EU requirements regarding the biodiversity impact assessment of roads (Vaiškūnaitė et al., 2012). Two studies considered legal issues related to marine conservation within Natura 2000. While Metcalfe et al. (2013) highlighted criticisms against the Habitats Directive as being ill-suited for marine conservation, Rees et al. (2013) claimed that “site integrity” and “favourable conservation status” are powerful legal terms that can facilitate effective marine conservation if fully transposed into the legislation of the EU Member States.

The remaining studies investigated the extent to which legal requirements regarding Natura 2000 incorporate considerations for some particular issues, such as climate change (Cliquet, 2014; Jackson, 2011) or the provision of ecosystem services (Kistenkas, 2014).

According to Cliquet (2014), although the Natura 2000 legislation does not explicitly mention climate change, it “contain[s] sufficient tools to deal with the effects of climate change”. Still, Cliquet (2014) argued that these tools have been insufficiently implemented so far and provided recommendations for improvement (see Table in online Appendix). On the contrary, Jackson (2011) suggested that legislation linked to Natura 2000 may potentially undermine climate change mitigation efforts by challenging many renewable energy projects. The author proposed to broaden the range of acceptable alternatives, and saw much potential in combining lower-impact renewable energy projects with Natura 2000 protection. Kistenkas (2014) advocated incorporation of the ecosystem services concept into EU's nature conservation law, emphasising that the present legislation is too rigid to enable proper assessment of these services.

3.2.6. Governance

The main focus of the papers in this category was on the effects of the implementation of Natura 2000 and, particularly, on the accompanying governance shifts. They described the general shift towards increased inclusion of more relevant stakeholders (Ferranti et al., 2014), the emergence of multilevel governance and an associated increase in implementation legitimacy (Niedziałkowski et al., 2012; Rauschmayer, 2009) with important input from environmental non-governmental organisations (NGOs) (Börzel and Buzogány, 2010; Cent et al., 2013; Weber and Christophersen, 2002). For example, both in Poland and Hungary, NGOs contributed strongly to the selection of Natura 2000 sites (Cent et al., 2013). In the course of action, the agendas and actions may change, which can contribute to increase in professionalization and institutionalisation of civil society groups (Börzel and Buzogány, 2010). However, this does not always result in sustainable cooperative state-society relations, particularly when both state actors and civil society are weak (Börzel and Buzogány, 2010). For example, Central Eastern European countries (CEE) are still characterised by top-down policy making. Here, conflict is still the main driver of the implementation of participatory processes (Rauschmayer, 2009), although there has been a recent shift to more multilevel governance in decision making (Niedziałkowski et al., 2012) and growing importance of NGOs in biodiversity conservation (Cent et al., 2013).

In Romania, Stringer and Paavola (2013) observed a lack of NGO involvement in the implementation of Natura 2000 and generally limited experience in public participation. They suggested that this is due to historical legacies of low participation and government reluctance towards more inclusive governance. Even in cases where governance shifts can be observed, there can be a gap between the rhetoric and practice of inclusive governance (Rauschmayer, 2009). Nevertheless, Börzel and Buzogány (2010) argued that an effective implementation of EU policies requires departure from top-down centralised steering, and that it demands meaningful inclusion of non-state stakeholders. Such shift can also address the existing problem of low acceptance of EU conservation policies, particularly among landowners (Weber and Christophersen, 2002).

3.2.7. Policy integration

This relatively small category included five papers that looked into integration of nature conservation policies concerning Natura 2000 with policies from other sectors. It was shown that policies and debates on issues other than conservation, e.g. agricultural land use (Koutseris, 2006), climate change (de Koning et al., 2014; Roggema, 2009), or noise protection (Votsi et al., 2014b) can affect conservation and management under Natura 2000 network. Thus better integration of different policies and Natura 2000 was advocated (Roggema, 2009; Votsi et al., 2014b).

3.2.8. Conservation priority setting

Several (4) papers discussed Natura 2000 implementation from the perspective of prioritization or systematic conservation planning. It was

argued that implementation of the network should make better use of systematic conservation planning (Gaston et al., 2008) incorporating socio-economic indices or human related criteria (Giakoumi et al., 2011; Tsiadou et al., 2013) to facilitate the achievement of conservation goals. This may lead to very different outcomes on the ground compared to less systematic approaches. For example, by using spatial prioritization software including innovative socio-economic cost indices in the eastern Mediterranean Sea, Giakoumi et al. (2011) showed that only a few of the sites selected through the systematic approach overlapped with those previously identified in an unsystematic way.

3.2.9. Participation evaluation

Four studies directly evaluated the participation processes related to Natura 2000 – either during the designation of the network (Apostolopoulou et al., 2012; Cent et al., 2014), or development and implementation of management plans (Engel et al., 2014; Young et al., 2013). The general picture was one of relatively low prevalence of participatory practices in Natura 2000. These were commonly rather superficial, operating mostly on paper (Apostolopoulou et al., 2012), and did not enable all relevant stakeholders to exert meaningful participation (Cent et al., 2014). The process of participation was usually steered in a top-down manner, with highly asymmetric power distribution among the involved actors. The governmental actors were the ones deciding who may participate and in what form (Apostolopoulou et al., 2012; Cent et al., 2014), aiming at fulfilling legal requirements or the needs of the organisers rather than empowering the participants (Cent et al., 2014). Even when the participation process was in principle open to everyone, a need for broader involvement of local people was expressed (Engel et al., 2014). In addition, in some cases there was a lack of formal governance structures that would require procedures of participation in decision making (Apostolopoulou et al., 2012). Overlapping responsibilities of management agencies, governance fragmentation and heavy bureaucracy led to many parallel co-decision procedures for a specific site, causing problems in terms of accountability and legitimacy of the process (Apostolopoulou et al., 2012). Moreover, lack of precise information and trust was identified as a barrier to a more effective participation process (Engel et al., 2014; Young et al., 2013).

Notwithstanding the above mentioned shortcomings, in three of the four studies in this category the participation process was deemed positive at least to some extent by the relevant stakeholders, as it increased their knowledge about and overall satisfaction with the Natura 2000 network (Cent et al., 2014), contributing to attitude changes towards the network (Young et al., 2013), and allowed the participants to contribute with their own knowledge and experiences (Engel et al., 2014).

4. Discussion

4.1. Main findings and their implications

The reviewed literature showed a very wide scope of topics, indicating that the social dimension of Natura 2000 is complex and multidimensional, and varies among EU countries. The introduction of Natura 2000 met the opposition of various stakeholder groups in almost all Member States. Thus, an implementation of Natura 2000 policy may require a definite shift towards recognition of a wide range of social aspects relevant to the particular contexts of individual countries. One of the most conspicuous aspects identified by our review was the question of public participation or, broadly, stakeholder involvement. There were relatively few papers that focused mostly on public participation and its role (included in 'Participation evaluation' category). Still, in several categories of papers such as e.g. 'Conservation conflicts', 'Management' or 'Perceptions', this issue was mentioned. The reviewed papers indicated a general trend towards more inclusive approaches in implementation and management of Natura 2000, practically at all stages. However,

stakeholder involvement, especially at the local level, was reported to be still of relatively small magnitude and low quality, and numerous challenges were identified. Even if new modes of governance emerged during the implementation and more power was given to non-state stakeholders such as NGOs or private landowners (Cent et al., 2013; Niedziałkowski et al., 2012) the effect was not always enduring. Sotirov et al. (2015) called such effect "symbolic transformation", where informal institution and practical behaviour did not change in line with formal domestic policy and institutions. This was particularly evident for the CEE countries that still bear some legacies of their communist past, characterised by top-down governance and practically no tradition of a broad stakeholder inclusion, especially those from non-public sector (Cherp, 2001; Kluvánková-Oravská et al., 2009). Yet, many studies underlined that meaningful participation is a key to successful Natura 2000 implementation and functioning and a necessary ingredient for efficient management of the sites. This is particularly important in the case of private land (e.g. farmland), as private landowners seem to be the most reluctant group in regard to the implementation of Natura 2000 requirements, due to potential limitations on land use (Geitzenauer et al., 2016). On the other hand, local governments seem to be a crucial group in the network's implementation and functioning, because Natura 2000 is in practice governed at the municipality level.

Our review revealed that although Natura 2000 was generally perceived as a useful conservation approach, there were also many negative perceptions of the network. The network was seen by many as an impediment to economic development. However, recent research from Poland (including all municipalities with at least one site of Natura 2000) did not support the assertion that the network was a significant negative barrier to economic development (Gutowska et al., unpublished). Indeed, a majority of municipalities were able to overcome the potential economic barriers, in most cases thanks to an operative local government. Our analysis showed, however, that the overall low representativeness and quality of stakeholder involvement could have greatly contributed to negative perceptions of Natura 2000, resulting in challenges in the network's implementation and functioning.

Another important obstacle reported in several studies was the low flexibility of the Natura 2000 regulations and their implementing authorities. It was emphasised that the local context matters, and hence that decisions based solely on strict rules and templates may not always be appropriate. This is particularly important with regard to the development of management plans for particular sites. Again, a participatory approach to management planning, with meaningful involvement of all relevant stakeholders, was suggested as a key component. A wide range of socio-cultural, institutional and discursive factors may influence the probability of success or failure of policy implementation, and thus taking them into considerations is essential (Hilding-Rydevik and Bjarnadottir, 2007; Runhaar, 2009). Implementation and functioning of Natura 2000 in various Member States is linked to multiple processes at different policy levels and depends on case-specific interplay (Borrass et al., 2015). A large diversity of approaches to implementation can be seen as a strength, as it can enable learning for improved future functioning of Natura 2000 (Winkel et al., 2015). However, to utilise this potential, there is a need for improved platforms and mechanisms of learning across the Member States (Winkel et al., 2015).

Some studies underlined the temporal aspects of Natura 2000 implementation. As Natura 2000 was implemented very quickly in many countries, it was not surprising that the process was not ideal (Kati et al., 2015). However, as Europe currently faces the next step of the network's implementation, i.e. creation and implementation of management plans for specific sites, the process could be improved by taking better consideration of the local context. Guidelines concerning organisation of the stakeholder involvement process (e.g. Bots et al., 2011; Hiedanpää, 2002) could be helpful in that respect.

Finally, the review has shown many implementation problems related to the low capacity of local actors. This suggests that a better flow of know-how from the EU to the local level, a larger number of better

qualified staff and adequate funding are necessary components of successful implementation and functioning of the network. In their survey of conservation scientists on the functioning of Natura 2000 implementation, Kati et al. (2015) also underlined the low political will of both national and local authorities to fulfil the goals of Natura 2000. They underlined the need for mechanisms strengthening the linkages between EU policy and national, regional and local administration levels.

4.2. Research gaps

Our analysis has shown unequal distribution of social-science research about Natura 2000 among the different EU countries. In general, there were fewer studies addressing the countries that entered the EU in 2004 or later (i.e. the non-EU-15 countries). Obviously, this could be a result of a later implementation of Natura 2000 in these countries, leading to a delay in associated research. However, as discussed by Popescu et al. (2014), this issue is more complex. According to these authors, the “new” EU countries only lagged behind EU-15 by a relatively short time (3 to 5 years) in the designation of Natura 2000 sites. Nevertheless, even this short time lag could have contributed to the observed differences in research effort. An additional contributing factor could be the relatively lower levels of research funding in the countries in economic transition compared to the EU-15 countries. However, there were also exceptions, where some of the late-accession countries (e.g. Poland) were represented in more papers than some of the EU-15 countries, which possibly could be explained by the higher importance of particular social issues in these countries (e.g. linked to more conflictual situations), or the presence of particularly productive research groups in some countries. Moreover, it must be kept in mind that our review only includes peer-reviewed scientific articles in English. This could have led to some bias, as some issues may have been covered in the grey literature or in references published in other languages. Particularly, this could have led to underrepresentation of findings of practical relevance, such as e.g. local-specific challenges faced by various stakeholders groups (e.g. the site managers) or best-practice solutions to particular cases on the ground. Still, our review presents a reliable overview of the body of knowledge which is broadly available to the international scientific community. As such, it could contribute to the EU fitness check and to the recommendations for improving Natura 2000 implementation and functioning; however, one should keep in mind the limitations of such review, and whenever possible complement our findings with existing local recommendations and guidelines.

Several additional gaps could be identified in the body of social-science research concerning Natura 2000. First of all, in spite of the widely recognised importance of the participation of various stakeholders in the implementation and operation of the network, relatively few studies have evaluated in detail the participation processes linked to Natura 2000. It is possible that such information could be found in grey literature for the local studies but such literature was not a focus of our review. Particularly, there is a need for more research on the importance of participation for actual conservation outcomes, i.e. the extent to which participation affects biodiversity on the ground. Rauschmayer et al. (2009) suggested that both the process and outcomes of natural resources governance need to be investigated if we are to judge its effectiveness. In the case of participation, some studies evaluated the process itself (e.g. in terms of good or deliberative participation), but its effects on biodiversity were rarely scrutinised (Reed, 2008). Young et al. (2013) have investigated the correlation between the quality of stakeholders' involvement and the future biodiversity outcomes as perceived by the stakeholders, but they could find clear relationship between the process quality and the perceived outcome only in some cases. Although it was confirmed that in general a better quality of participation had a positive impact on social outcomes and particularly trust and justice, more studies are needed to confirm if the improved participation also leads to improved ecological outcomes. As public participation is still rather undeveloped in the majority of the EU countries, insights from

such studies could provide useful knowledge for improving the further steps of Natura 2000 implementation and functioning. However, one needs to keep in mind that not only the participation process, but also different external factors may influence the ultimate conservation outcomes. Nevertheless, participatory approaches could be useful in the development of management plans for Natura 2000 (Hochkirch et al., 2013), as they increase trust among stakeholders and enable better integration of their different values, potentially allowing for better conservation outcomes (Williams, 2011; Young et al., 2013).

Better participation may practically lead to improved engagement in conservation and increased awareness of the conservation needs. Also, participatory process may contribute to Natura 2000 managers' understanding of the potential reasons for the resistance towards the network. At the same time, there is a need for studies investigating the potential effects of education and increasing awareness on people's perceptions of Natura 2000 and potential attitude changes. Although cognitive approaches alone proved not to be sufficient in furthering attitude change (Heberlein, 2012), they are an important component of strategies for dealing with environmental issues (Gardner and Stern, 1996). The importance of increasing the public awareness on Natura 2000, especially at the local level, was also underlined in a large survey of conservation scientists recently carried out by Kati et al. (2015). Our review has shown that there is still low acceptance of the Natura 2000 network in society, and a lack of knowledge on the network operation can be a factor contributing to it. As social acceptance is an important prerequisite for the implementation of conservation policies, there is a need for increased efforts, e.g. in terms of education and information, aiming at raising this acceptance (Kati et al., 2015). Still, although education and information are important, they are not sufficient for facilitating social acceptance. There is thus a need to also explore what other factors (in addition to low awareness) contribute to the resistance against the network in many places.

In addition, the low acceptance of the network by landowners may suggest that there is a need for compensatory measures, such as reimbursement of the conservation costs incurred by the private land owners (Kamal and Grodzinska-Jurczak, 2014; Schröter-Schlaack et al., 2014). For example, Stancioiu et al. (2010) suggested the need for compensatory financial mechanisms to cover the costs of Natura 2000 for the land owners. Also, conservation scientists surveyed by Kati et al. (2015) highlighted the need for an independent funding mechanism entirely devoted to supporting implementation of Natura 2000 goals. Also Winkel et al. (2015) suggested the need for development of a coherent funding strategy for Natura 2000 based on comprehensive assessment of both current spending and financial needs for the network. This may be particularly important for the CEE countries with extensive rural areas, large coverage of Natura 2000 sites and lower level of economic development compared to the EU-15 countries (Pavasars, 2013; Stancioiu et al., 2010). To design effective financing mechanisms that support the network, we see a need for more studies analysing the effects of alternative compensatory approaches in a range of socio-economic settings, on e.g. acceptance of conservation or biodiversity outcomes; however our review have revealed that such studies are still rare.

The issue of effectiveness has been largely neglected in the social research about Natura 2000. Very few studies looked at the costs or the benefits of the network, and comprehensive economic analyses were entirely missing in the reviewed publications. Surprisingly, the concept of ecosystem services was very rarely utilised in social-science research about Natura 2000, although it may seem particularly well fitted to analysing the complex socio-ecological systems of Natura 2000 sites (Primmer et al., 2015; Soane et al., 2012). Ecosystem service research could, for example, aim to identify and quantify potential benefits from the protection of the Natura 2000 sites, which in term could contribute to wider acceptance of the network (Cruz et al., 2011). Research on the effectiveness of the Natura 2000 network should also involve studies developing and testing indicators of effectiveness, including both ecological indicators as well as indicators of the social dimension

encompassing human actions, institutions, organisations and networks (Salafsky et al., 2002). Such indicators are urgently needed to evaluate the success (or failure) of the network.

Conservation does not operate in an empty space. Rather, it is an integral part of complex socio-ecological systems. Consequently, insufficient consideration of social aspects risks undermining conservation effectiveness, while integrating local human context in the protected areas facilitates achieving biological conservation and socioeconomic development outcomes (Oldekop et al., 2016). Although Natura 2000 is generally seen as a successful conservation endeavour (Kati et al., 2015), our review points to different shortcomings affecting practically all EU Member States. Social science research has a great potential to contribute to the knowledge base necessary for improving the situation. Particularly, the knowledge derived from the social science investigations could contribute to the ongoing Natura 2000 fitness check (EC, 2015b), by pointing to the areas in the network's implementation and functioning that need to be improved.

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Appendix A. Supplementary data

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