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Seeking consensus in German forest conservation: An analysis of contemporary concepts

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Abstract

Setting operational conservation objectives is a major challenge for effective biodiversity conservation worldwide. To analyse forest conservation objectives in Germany in a transparent manner and to achieve a consistent and consensual framework, we systematically classified conservation objectives suggested in concepts by different stakeholders. We analysed 79 biodiversity and forest conservation concepts of different stakeholder groups at various scales and applied textual content analysis and Dirichlet regression to reach a high degree of transferability and applicability. Our analysis revealed a broad consensus concerning forest conservation across stakeholders and scales, albeit with slight differences in focus, but we detected a scale-related mismatch. A wide array of conservation objectives covered social, biotic and abiotic natural resources. Conservation of species, ecosystems and structural elements in forests were found to be of primary importance across stakeholders and scale levels. Shortcomings in the conservation concepts were found in addressing genetic diversity, abiotic resources and socio-cultural objectives. Our results show that problems in forest conservation may be rooted in trade-offs between aims, targeting mismatch across scale levels and insufficient implementation of objectives.

Keywords

biodiversity, conservation concepts, conservation objectives, Dirichlet regression, forest conservation, stakeholders, spatial scales, scale mismatch, targets

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Introduction

Twenty-five years after coming into force, the targets of the Convention on Biological Diversity (CBD) are yet to be reached. National and international strategy papers on nature conservation and sustainability have proliferated in the meantime (BMU 2018; Hagerman and Pelai 2016). However, implementation is often controversial and not all measures have been successful in achieving CBD targets. There is general agreement amongst conservationists, that biodiversity and its services to human well-being are still at high risk and that many actions have not succeeded in reducing these risks. For instance, Tittensor et al. (2014) concluded that, by 2020, the pressures affecting biodiversity will still be increasing and Ripple et al. (2017) warned that the global state of biodiversity conservation is more than worrying. Human-induced biodiversity loss is a matter of concern for all societal groups and from global to local levels (Masood 2018). It is beyond doubt that biodiversity decline is driven chiefly by unbridled habitat destruction and land-use intensification (Vellend et al. 2017; Tittensor et al. 2014; CBD 2010; Millennium Ecosystem Assessment 2005).

Effective conservation needs a consistent and comprehensive framework of conservation objectives. Such a framework should aim at preserving wildlife species, as well as ecosystems as a whole. Moreover, the sustainable production and use of natural products such as food, timber, minerals and other resources for human needs, as well as the non-material benefits of recreation, amenity, culture and science, are to be considered (Harley 1977). Perrings et al. (2011) emphasised that frameworks should indeed reflect and consider human well-being and the benefits people enjoy and gain by protecting biodiversity and securing its ecosystem services. To enhance biodiversity-friendly land-use, it is crucial to develop nested knowledge systems (Cornell et al. 2013), which are harmonised across scales and groups of stakeholders (Peterson et al. 2018).

The limited success of nature conservation efforts can also be attributed to scale mismatches within frameworks of conservation objectives (Guerrero et al. 2013). Scale mismatches (temporal, functional or spatial) arise when social-ecological functions are disrupted across the scales of the managing social and environmental organisations and when environmental problems are the result of mismatches between the scales of human responsibility and natural resources (Cumming et al. 2006; Lee 1993). Within stakeholder groups (e.g. administrations, conservation associations, forest enterprises), conservation objectives should ideally be nested and harmonised across scales, enabling unimpeded conceptual transfer and exchange of knowledge. As ecological processes and ecosystem functions vary across scales (Peterson et al. 1998), overcoming scale mismatches is of particular importance for the successful implementation of conservation objectives (Ahlborg and Nightingale 2012; Paloniemi et al. 2012). It is essential to reveal framework inconsistencies and whether conservation objectives deviate amongst stakeholders and between spatial scales and, if so, in which respect (Guerrero et al. 2013). Several studies found that insufficient definitions of objectives and inconsistencies in frameworks are major obstacles for effective nature conservation (Butchart et al. 2016; Meyer et al. 2016; Maxwell et al. 2015; Stafford-Smith 2014; Marquard et al.

2013; Heink and Kowarik 2010; Kapos et al. 2008; Tear et al. 2005). Different stakeholder expectations may be a major reason for such deficiencies. This study aims at bridging these obstacles by providing a conceptual contribution to the ongoing debate in nature conservation.

Multiple approaches exist to frame nature conservation, provide tools and justify actions (Mace 2014). The People and Nature approach tries to encompass ideas and disciplines by interrelating the protection of nature with the services it provides for human well-being (Carpenter et al. 2009; Mace 2014). In contrast, the Nature's Contribution to People approach, developed by the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), and the Provisioning, Regulating and Maintenance and Cultural Ecosystem Services (CICES; Haines-Young and Potschin-Young 2018), look at nature conservation in a more utilitarian way. These approaches have a wider focus than the general ecosystem service framework (Millennium Ecosystem Assessment 2005), as they also include social and cultural standards (Díaz et al. 2018).

In fulfilment of the obligations of CBD, article 6, Germany adopted a National Strategy on Biological Diversity, comprising 330 targets and around 430 measures (BMUB 2007), many of them involving forest ecosystems. Subsequently, individual German federal states as well as state forestry enterprises and non-governmental organisations published separate regional biodiversity and nature conservation concepts. In Germany, where forests cover approximately one third of the land area, close-to-nature forest management and sustainable use of forest products are priority components of these concepts. With respect to forest conservation, our overall objectives were

(1) to derive a comprehensive and conceptual reference framework of German forest conservation objectives based on contemporary concepts to classify and systematically analyse the conservation objectives in terms of completeness and consistency;
(2) to reapply the results to conservation concepts in search of commonalities and differences and to examine the comprehensive nature of concepts.

Assuming a wide range of different interests, we hypothesised considerable variation between the conservation concepts and objectives provided by different stakeholders but, nevertheless, scale-independent consensus (meaning a balanced knowledge transfer) within particular groups of stakeholders. Another aim was thus to verify unimpeded conceptual transfer of knowledge within stakeholder groups across scales.

Methods

Deriving a reference framework of conservation objectives

We define a conservation objective (CO hereafter) as the combination of a physical object of conservation, e.g. organisms, biotopes, soil or water resources and the properties of its desired state (target). We derived a comprehensive reference framework of COs

Table 1. Classification framework of conservation objectives (for a detailed list see Suppl. material 1: Table S1).

Level	Conservation objective	Specification	Code
1	General field of conservation	Socio-political	S
		Nature conservation *sensu stricto*	N
2	Field of natural resources	Abiotic environment	A
		Biotic environment	B
3	Mainly abiotic targets	Soil	S
		Water	W
		Climate	C
	Mainly biotic targets	Genetic diversity	G
		Species	S
		Ecosystems and biotopes	E
		Landscapes	L
4	Categories of natural resources	Processes	P
		Structures, elements	S
		Functions = cross-connecting various levels	F
5	Qualities and properties of natural resources	Diversity	D
		"Typicalness"	T
		Completeness, integrity	C
6	Management dependency	Self-sustaining	S
		Management-dependent, culture-bound	M

by referring to the CBD (United Nations 1992a) and the German Nature Conservation and Landscape Management Act (BNatSchG, as amended on 29 July 2009). The BNatSchG, in its Article 1 (1), defines the purpose of nature conservation and landscape management as to "permanently safeguard (1) biological diversity, (2) the performance and functioning of the balance of nature, including the ability of natural resources to regenerate and lend themselves to sustainable use and (3) the diversity, characteristic features and beauty of nature and landscape, as well as their recreational value" (BMU 2010). According to both CBD and BNatSchG, biological diversity is defined as the variability amongst living organisms, terrestrial, marine and freshwater and the ecological complexes of which they are part; this includes interactions within species, between species and communities, ecosystems and biotopes (United Nations 1992a).

For each objective, we defined six levels of potential hierarchical classification depth of COs (Table 1). Relationships between levels of COs were understood as functions and indicated separately. Each single observation within the framework of COs was described as a target. For instance, the target "forest bog ecosystem" was described by the cross-connected code NBEF(NAC), as bogs are ecosystems functioning as important long-term carbon sinks (Moore and Knowles 1989), hence contributing to climate protection. With this approach, we identified and described even rather complex and interlinked relationships, reflecting multi-layered environmental patterns and processes. Each single target received a code (a combination of letters) representing a certain level of the framework of COs.

At the first level of differentiation (general field of conservation), COs were classified into the categories socio-political (e.g. recreation, enhancement of tourism, stimulating financial funding for conservation, legal issues, awareness-raising) or nature conservation *sensu stricto*. For socio-political COs, no further differentiation was deemed necessary, but cross-connections were possible (Suppl. material 1: Table S1). COs of nature conservation *sensu stricto* were grouped into abiotic and biotic objectives. The latter were further grouped to cover genetic, species and ecosystem diversity (in accordance with the CBD) and landscape diversity, as this is stressed in the BNatSchG. Our differentiation of abiotic and biotic natural resources is compatible with the CICES themes and classes of ecosystem services: provisioning, regulating and maintenance and cultural (Haines-Young and Potschin-Young 2018; Haines-Young and Potschin 2011).

To give each objective more detail, we developed further levels concerning categories of natural resources, qualities and conditions of existence (Table 1). We distinguished between COs related to processes, structures or functions and further, by CO addressing diversity as such, typical features or integrity/intactness. At the final level, we differentiated between self-sustaining and management-dependent systems.

A specific code was assigned to each CO (Suppl. material 1: Table S1). However, as the classification system had to deploy an operational level, some specific targets fall under the same generalised category and could not be detected separately. The code NBESTS, for example, comprises all targets concerning self-sustaining ecosystem structures.

Finally, individual target keywords were added to address more specific cases. For instance, the code NBESCS, addressing the integrity of self-sustaining ecosystems, was further detailed by the target keyword "protection of beech forest ecosystems". A detailed list of all target keywords and their assigned codes can be found in Suppl. material 1: Table S2.

Textual content analysis

We conducted textual content analyses of 79 biodiversity and forest conservation concepts (for a detailed list of concepts, see Suppl. material 1: Table S3). The concepts were collected via web-based literature research on the websites of different stakeholders. We selected and gathered all current concepts and strategies published until 2016, covering all relevant stakeholder groups. Single forest owners or private forest enterprises were not analysed, as they did not develop their own valid forest conservation concepts. Furthermore local or municipal groups were excluded as well to ensure comparability amongst all stakeholders.

We classified the stakeholders into three pre-defined groups; administrative institutions (e.g. ministries), nature conservation NGOs and state forestry enterprises (Table 2). Furthermore, each concept was assigned to a specific concept type: general nature and biodiversity conservation related concepts; specific forest conservation concepts; concepts addressing forest management and silviculture; general forest programmes; and specific concepts addressing veteran tree and deadwood management.

In terms of scale, the concepts were referable to international, national (Germany) or regional (federal states) levels (Table 2). For the definition of scale, we refer to Gibson et al. (2000) and Cash et al. (2006), who state that scale has many different

Table 2. Categorisation of concepts with their abbreviations (Abbr.) and numbers of concepts per stakeholder group and jurisdictional scale level (Int = International, Nat = National, Reg = Regional).

Stakeholder	Abbr.	Concept type	Jurisdictional scale levels		
			Int	Nat	Reg
Concepts published by administrative or governmental institutions (e.g. ministries)	Instit	Biodiversity	3	2	14
		Forest conservation	1	–	2
		Forest management	–	–	3
		Forest programme	–	1	4
		Veteran trees and deadwood	–	–	–
Concepts originated under the leadership of state forestry enterprises	StateF	Biodiversity	–	–	–
		Forest conservation	–	–	10
		Forest management	–	–	14
		Forest programme	–	–	2
		Veteran trees and deadwood	–	–	6
Concepts published by environmental and nature conservation NGOs	NGO	Biodiversity	–	1	1
		Forest conservation	–	8	4
		Forest management	–	1	–
		Forest programme	–	–	1
		Veteran trees and deadwood	–	–	1

dimensions (e.g. spatial, temporal, jurisdictional, institutional), each having different levels, "units of analysis that are located at different positions on a scale" (Cash et al. 2006). The international, national and regional levels refer to the jurisdictional scales (administrations) (Cash et al. 2006).

Textual content analysis was used to identify and interpret the COs. Content analysis is a standard research method in social sciences and is used to gather and scrutinise text, the content of which "can be words, meanings, pictures, symbols, ideas, themes or any communicated message" (Neuman 2014). Qualitative (descriptive) and quantitative (numerical) content analyses can be distinguished and the former may be "defined as a research method for the subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns" (Hsieh and Shannon 2005). To ensure scientific transparency and reproducibility throughout the process of content analysis, all concepts were read twice. During that second stage, falsely assigned COs were reassigned to another code and neglected ones were newly described. Each identified CO was categorised according to the classification system.

Data analysis

For each concept, all individual CO code assignments were treated as single observations and each hierarchical level of classification (Table 1) was analysed separately. The relative importance of a certain objective was determined by dividing the number of targets assigned to the CO by the overall sum of targets registered in the concept. This procedure generates vectors of shares of targets, distributed along the CO. Each vector contains non-independent elements and must be treated as one observation per concept. We used Dirichlet distribution as a statistical model suitable for describing the mechanisms underlying such observations. Dirichlet regression (Maier 2014) is a statistical method for working out differences in the expected composition of such vectors – that is, the collection of expected values (EV) of the vector elements – according to differences in explanatory variables. Presented results are based on the estimated EV and their uncertainties quantified in uncertainty intervals. If one of the observed vectors – belonging to one specific CO – contains an element that has a value of zero, this CO had no target mentioned in a concept. As all concepts in this study are related to nature conservation, we assumed that each of these underlie minimal shares of concern for each CO. Based on this assumption, we treated zero observations as "rounded zeros" (Martín-Fernández et al. 2003), which enabled us to lift zero values up to small positive values based on the transformation proposed by Maier (2014). This makes the use of Dirichlet regression possible, as it requires values between 0 and 1. We ran the Dirichlet regression model (Maier 2014) with concept type as categorical explanatory variables. All analyses were performed using the STAN Bayesian inference environment (Carpenter et al. 2017). For technical details of the model fitting process, see Sennhenn-Reulen (2018). Of the several prior choices described by Sennhenn-Reulen (2018), we used the N (0.5) prior for all model coefficients. Results are displayed as posterior means (Jaynes 2003) in percentages. With this standardised method, the relevance for forest conservation of each CO level was ensured for all concepts. Furthermore, the motivation for protecting and securing forest biodiversity of each stakeholder group could be assessed and evaluated.

With respect to orthogonality, it is critical that not all stakeholders are represented on all jurisdictional levels (Table 2). Thus, the analysis of the effect of the stakeholder group was conducted only at the regional level, reducing the sample size to 62 concepts. To analyse the effect of scale, only administrative concepts were assessed, reducing sample size to 30. In this stakeholder group, we expected content-related harmonisation across the levels.

To further analyse the degree of specification within the stakeholder group of administrative institutions, a level-of-detail-analysis was conducted. To allow for sufficient specification, we restricted the analysis to biotic COs (genes, species, ecosystems and landscape, see Table 1) at the third level. The level of detail was equal to the maximum hierarchical level reached (Table 3). The analysis was conducted for each biotic CO separately and mean specification degrees were calculated for each concept. For the analysis of the keywords, counts or mentions (presence/absence) per concept were calculated.

Table 3. Specification degree of conservation objectives.

Conservation objective	Level of Detail
No further specification of biotic objective	0
Categories of natural resources	1
Qualities and properties of natural resources	2
Management dependency	3

Results

Commonalities and differences between conservation concepts

The textual content analysis of 79 concepts revealed a broad range of single COs. In total, 170 individual targets (keyword combinations) were detected, with between 14 and 85 (mean 50) targets per concept. On average, a single concept covered 30% of the overall number of targets.

All stakeholders clearly prefer nature conservation *sensu stricto* instead of socio-political COs (Table 4). The EV for the social-political targets ranged between 8% and 11%. The highest values were found in the concepts of nature conservation NGOs (NGO) and administrative-governmental institutions (Instit), the latter significantly differing from state forestry enterprises (StateF). The highest percentages, albeit insignificant, of socio-political targets were found in national and international concepts.

Our results show that COs consider protecting the biotic environment generally more important than abiotic resources (Table 4). Even though biotic targets are pursued at all spatial scales, regional institutions have significantly higher percentage values than international institutions.

Ecosystem and species diversity are the main biotic COs in all analysed concepts, followed by, but with considerably lower percentages, the protection of landscape elements (Figures 1 and 2). In contrast, the protection of genetic diversity and of all elements of abiotic resources (soil, water and climate) is considered as of minor relevance. Within regional stakeholders (Figure 1), Instit had significantly lower proportions for the most frequently mentioned targets (protection of ecosystem and species diversity) than NGO and StateF. Regarding the protection of landscape diversity, Instit concepts had significantly higher values than the other stakeholder groups. Targets for the protection of soil, water, climate and genetic diversity were scarcely mentioned by all stakeholder groups, with EV mainly lower than 5%. Apart from soil-related COs, where Instit had lower proportions than the other two groups, no significant differences were found between the stakeholder groups. However, this difference is based on lower sample size and not discussed further.

Regarding the scale effect, regional concepts exhibited a smaller range than the other levels (Figure 2). For international institutions, the protection of ecosystems turned out to be significantly less important than for national and regional institutions. Species and ecosystem protection were similarly relevant in international concepts, whereas in national or regional concepts, the protection of species was less frequently mentioned. The protection of landscape elements was found to be of minor importance at all levels. With decreasing scale level, the necessity for protecting genetic diversity and abiotic resources was noted decreasingly, although this effect was not significant.

The results concerning the category (Table 5), quality (Table 6) and conditions of existence (Table 7) showed that the general focus in all concepts – regardless of the specific stakeholder group or scale level – lies in protecting diverse and naturally self-sustaining structures of forest ecosystems. Targets for the protection of processes or natural dynam-

Table 4. Proportions (expected values, in %) of the first and second classification level of conservation objectives.

		General field of conservation			Natural resources		
		Socio-political	Nature conservation	*	Abiotic	Biotic	*
Regional stakeholder	Instit (n=23)	10.3	89.7	*a*	8.0	92.0	*a*
	NGO (n=7)	11.1	88.9	*ab*	6.3	93.7	*a*
	StateF (n=32)	7.6	92.4	*b*	6.5	93.5	*a*
Jurisdictional scale	Int (n=4)	13.7	86.3	*a*	14.2	85.8	*a*
	Nat (n=3)	13.1	86.9	*a*	11.6	88.5	*ab*
	Reg (n=23)	9.5	90.6	*a*	6.9	93.1	*b*

Instit = Administrative-governmental institutions, NGO = Non-governmental organisations or nature conservation associations, StateF = State forestry enterprises, Int = International, Nat = National, Reg = Regional, * = different letters indicate significant differences between stakeholder groups and between scale levels.

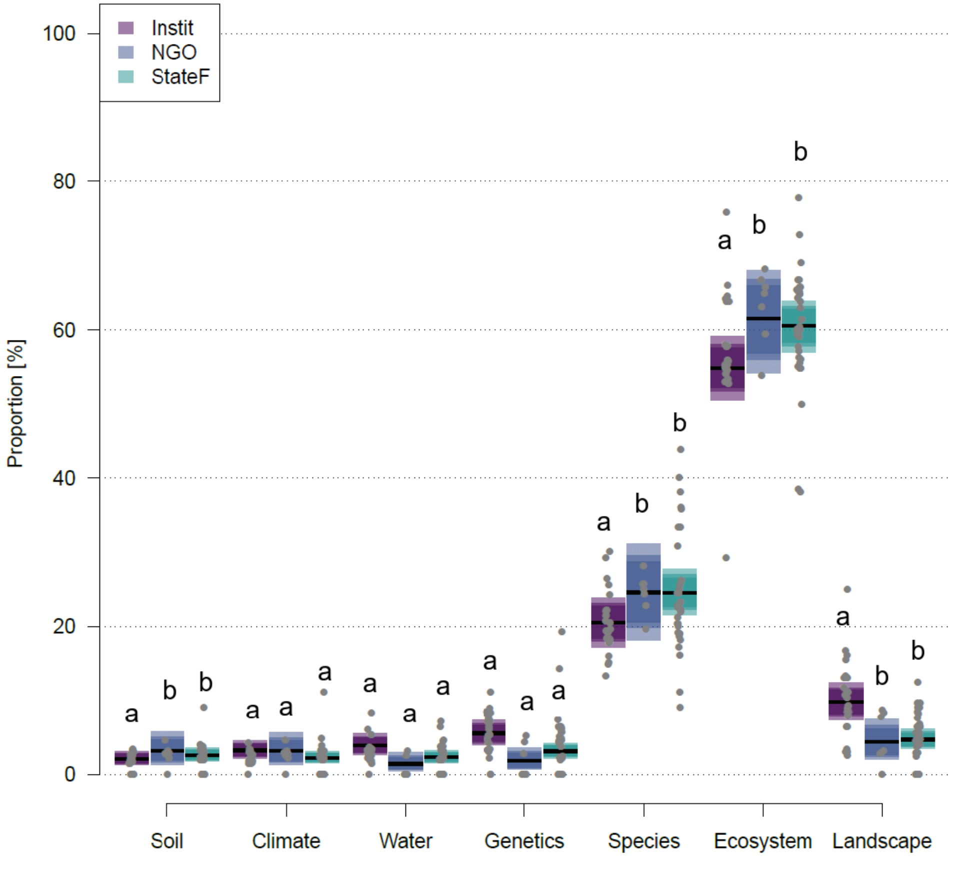

Figure 1. Stakeholder impact – posterior means for the third level of COs for the three stakeholder groups (n = 62). Different letters indicate significant differences between stakeholder groups (Instit = administrative-governmental institutions, NGO = environment or nature conservation NGOs, StateF = State forestry enterprises). Displayed are the expected value (black line), the 99% (light), the 95% (medium) and the 90% (dark) uncertainty intervals.

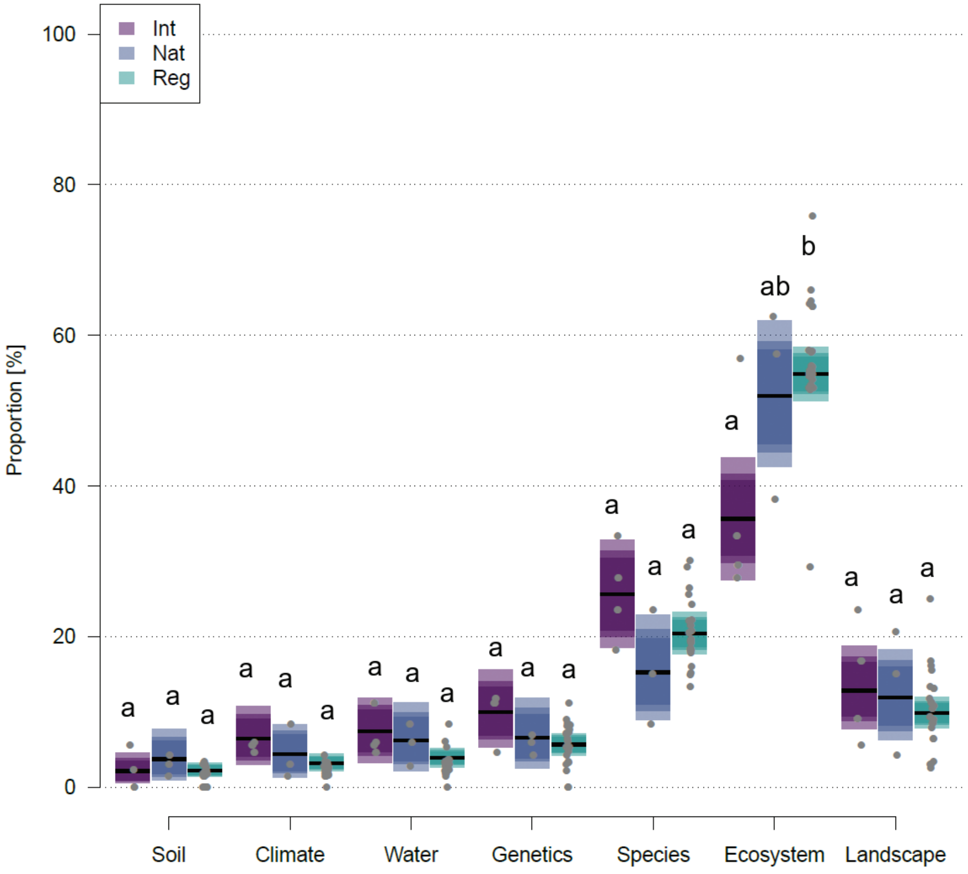

Figure 2. Jurisdictional scale effect – posterior means for the third level of COs for the three spatial scales (n = 30). Different letters indicate significant differences between scales (Int = International, Nat = National, Reg = Regional). Displayed are the expected value (black line), the 99% (light), the 95% (medium) and the 90% (dark) uncertainty intervals.

ics (fourth level: e.g. natural forest cycles; natural forest regeneration; habitat continuity) were the least mentioned by the stakeholders, with NGO having significantly higher percentage values than Instit and StateF (Table 5). For international institutions significantly lower values regarding natural dynamics protection were found than for regional ones.

The significantly highest percentages of targets with functions/cross-connections to other CO levels were found in international concepts. Cross-connections were either in relation to socio-political targets (e.g. a social responsibility to protect species; forest habitats as a place for recreation and tourism) or to abiotic targets (e.g. preservation or development of climate-resilient forest stands; water supply by forests). Here, StateF had significantly lower percentages than NGO. In general, protecting particular elements and structures (e.g. specific forest or species communities; habitat trees; biotope

Table 5. Proportions (EV, in %) of the fourth level to describe the categories of conservation objectives.

		Functions/ cross-connections	*	Processes	*	Structures, elements	*
Regional stakeholder	Instit (n=23)	24.7	*ab*	14.0	*a*	61.3	*a*
	NGO (n=7)	28.3	*a*	20.8	*b*	50.9	*b*
	StateF (n=32)	22.6	*b*	13.9	*a*	63.5	*a*
Jurisdictional scale	Int (n=4)	49.4	*a*	3.3	*a*	47.4	*a*
	Nat (n=3)	30.3	*b*	12.3	*ab*	57.5	*ab*
	Reg (n=23)	25.0	*b*	14.6	*b*	60.4	*b*

Instit = administrative-governmental institutions, NGO = environmental and nature conservation NGOs, StateF = State forestry enterprises, Int = International, Nat = National, Reg = Regional, * = different letters indicate significant differences between stakeholder groups and between scale levels.

Table 6. Proportions (EV, in %) of the fifth level to describe the qualities of conservation objectives.

		Diversity	*	"Typicalness"	*	Completeness	*
Regional stakeholder	Instit (n=23)	53.6	*a*	40.7	*a*	5.6	*a*
	NGO (n=7)	47.2	*a*	49.5	*a*	3.3	*a*
	StateF (n=32)	56.2	*a*	39.9	*a*	3.9	*a*
Jurisdictional scale	Int (n=4)	76.7	*a*	20.7	*a*	2.6	*a*
	Nat (n=3)	46.5	*b*	43.1	*a*	10.5	*b*
	Reg (n=23)	53.6	*b*	40.6	*a*	5.8	*b*

Instit = administrative-governmental institutions, NGO = environmental and nature conservation NGOs, StateF = State forestry enterprises, Int = International, Nat = National, Reg = Regional, * = different letters indicate significant differences between stakeholder groups and between scale levels.

Table 7. Proportions (EV, in %) of the sixth level to describe the conditions of existence of conservation objectives.

		Management-dependent	Self-sustaining	*
Regional stakeholder	Instit (n=23)	22.2	77.9	*a*
	NGO (n=7)	9.2	90.9	*b*
	StateF (n=32)	20.5	79.5	*a*
Jurisdictional scale	Int (n=4)	7.4	92.6	*a*
	Nat (n=3)	25.2	74.8	*b*
	Reg (n=23)	21.5	78.5	*b*

Instit = administrative-governmental institutions, NGO = environmental and nature conservation NGOs, StateF = State forestry enterprises, Int = International, Nat = National, Reg = Regional, * = different letters indicate significant differences between stakeholder groups and between scale levels.

types; single species) plays a major role across almost all stakeholders and levels. However, StateF and Instit emphasise the protection of structural elements significantly more than NGO. This was also true at the regional level and partly so at the national level.

The fifth level describes particular qualities of COs (Table 6), focusing either on diversity (e.g. habitat or species diversity), qualitative characteristics (particular forms or features) or on attempting completeness, integrity or intactness of the CO. Such targets were commonly mentioned in all concepts. Significant differences were found between scale levels but not between stakeholder groups. At the international level, the main target was to protect a maximum degree of diversity. At national and regional levels, significantly lower percentages of this target were found. Generally, the aim to protect complete qualities of COs was found to be of relatively low priority at all levels, with the significantly lowest EV at the international level (Table 6).

On the sixth level, protecting self-sustaining biodiversity features was given priority across all stakeholders and scales (Table 7). This was particularly true for concepts by NGOs or at international level, which had the significantly highest percentage (EV) values. The maintenance of culture-bound and management-dependent systems was considered particularly important for Instit and StateF. Within institutions, it is more often addressed at the national and regional than at international level.

Degree of specification for administrative concepts

We assumed that the degree of specification would increase from the international to the regional level. However, this was not the case for COs related to genetic diversity and only weakly so for species and landscape diversity (Figure 3). Here, levels of detail mainly remained at the fifth overall level (Table 1). A clear, scale-dependent increase of specification could only be confirmed for the CO ecosystems. With respect to the CO landscape, the range is prominently higher at the regional than at the national and international levels.

Assessment of forest conservation target keywords

We distinguished a total of 107 target keywords in the concepts (Suppl. material 1: Table S3). While concepts of international administrations cover only 18% of all possible keywords, national ones included 40% and regional ones 44%. NGO and StateF generally cover about 30% and Instit 44% of all possible keywords. The protection of habitats was the most frequently mentioned target included in all concepts (Table 8). Targets such as the maintenance of deadwood in forest ecosystems, sustainable forestry, the social obligation to protect and secure species habitats, the implementation of a close-to-nature forest management and the protection of habitat trees were also very frequently mentioned. With on average approximately 60 mentions, the preservation of protected areas, as well as of habitats and species in the EU Natura 2000 network of conservation areas, also played a major role in the concepts. Keywords concerning the protection of particular forest biotopes (e.g. wooded heathland or fir forests) and of forest attributes with carbon sink functions (e.g. deadwood and old-growth forests) were comparatively rarely mentioned.

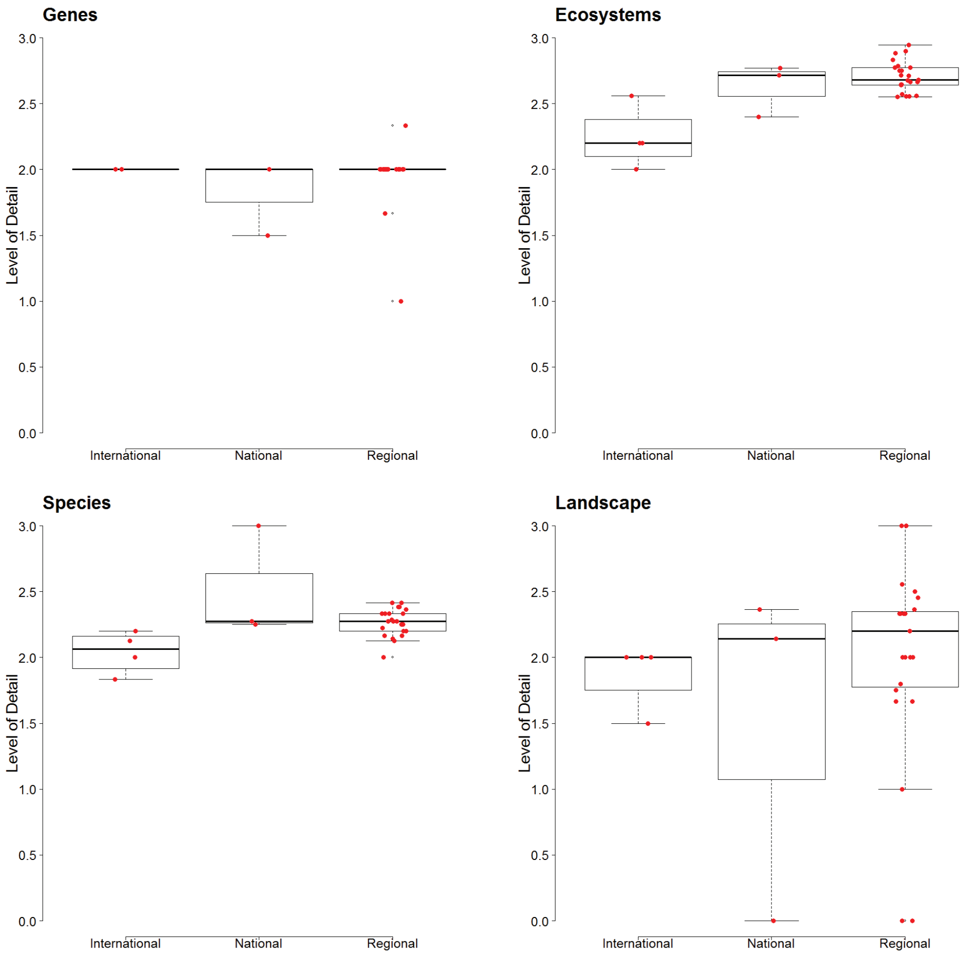

Figure 3. Level of detail (specification degree) for the four elements of biodiversity, genes, species, ecosystems and landscape, in relation to their scale levels (international n = 4, national n = 3 and regional n = 23).

Certain differences between administrative-governmental concepts (found at all scale levels) and between regional concepts (found in all different stakeholder groups) are worth mentioning. Regional concepts pay more attention to the protection of specific forest elements, such as habitat trees, deadwood-dependent species and old-growth forests. Administrative-governmental concepts, on the other hand, stress the importance of landscape- and connection-related elements, such as biotope networks, species stepping stones and riverine systems, while emphasising the need to finance forest conservation. Although not shown in Table 8, some keywords were non-exclusively claimed by all members of a specific stakeholder group or scale level. International institutions invariably mentioned habitat protection, sustainable forestry and ecosystem services. Likewise, national institutions all claimed sustainable forestry, biotope

Table 8. Absolute and percentage frequency of the most important keywords for all concepts, for administrative-governmental concepts at all levels and for regional concepts of all stakeholder groups, respectively (only keywords with > 40 mentions for all concepts are listed).

Keyword	All concepts (n = 79)	%	Administrative concepts (n = 30)	%	Regional concepts (n = 62)	%
Habitat protection	75	94.9	28	93.3	59	95.2
Deadwood in forest ecosystems	67	84.8	24	80.0	53	85.5
Sustainable forestry	65	82.3	27	90.0	50	80.6
Social obligation for habitat protection	65	82.3	21	70.0	51	82.3
Close-to-nature forestry	63	79.7	23	76.7	52	83.9
Habitat trees	63	79.7	20	66.7	52	83.9
Protected areas	62	78.5	26	86.7	46	74.2
Natura 2000 habitats	61	77.2	25	83.3	49	79.0
Natura 2000 species	59	74.7	24	80.0	47	75.8
Near-natural forests	59	74.7	24	80.0	46	74.2
Rare species	59	74.7	20	66.7	46	74.2
Forest structures	58	73.4	19	63.3	48	77.4
Naturally developing forests	58	73.4	20	66.7	46	74.2
Natural regeneration	54	68.4	19	63.3	45	72.6
Hunting	53	67.1	22	73.3	43	69.4
Natural forest reserves	52	65.8	18	60.0	42	67.7
Biotope network	51	64.6	26	86.7	40	64.5
Wetlands	51	64.6	20	66.7	41	66.1
Deadwood-dependent species	49	62.0	15	50.0	42	67.7
Forests developing stages	49	62.0	17	56.7	42	67.7
Old-growth forest	49	62.0	16	53.3	39	62.9
Species stepping stones	49	62.0	20	66.7	37	59.7
Forest edges	48	60.8	16	53.3	39	62.9
Beech forests	46	58.2	16	53.3	37	59.7
Mixed forests	46	58.2	22	73.3	41	66.1
Rare tree species	45	57.0	16	53.3	38	61.3
Bogs	44	55.7	21	70.0	38	61.3
Riverine systems	44	55.7	24	80.0	36	58.1
Traditional forest management	44	55.7	16	53.3	36	58.1
Certification	42	53.2	19	63.3	32	51.6
Forest conservation financing	42	53.2	18	60.0	28	45.2

networks and the maintenance of protected areas, wildlife species and near-natural forests. All NGOs pursue the purpose of habitat protection, protecting natural forest development and designating protected areas. Regional concepts emphasise specific forest conservation related keywords of local scope, such as the protection of deadwood and habitat trees, as well as close-to-nature forestry. This was particularly true for StateF and NGO. In the concepts of regional institutions, more general nature conservation statements were made, such as protecting Natura 2000 habitats and expanding biotope networks.

Discussion

Deriving and applying frameworks of conservation objectives

Many researchers examined and reviewed nature conservation concepts in general and the implementation of nature and forest conservation objectives in particular (Ulloa et al. 2018; Morales-Hidalgo et al. 2015; Moilanen et al. 2014; Pullin and Stewart 2006; Pullin et al. 2004; Sutherland et al. 2004). Amongst their findings was that it requires interdisciplinary collaboration, the integration of all fields of biodiversity research and a unifying frame of reference to be effective in conservation. As there is no review of forest conservation that could be used as a generalised reference frame, the framework of forest COs we derived may serve as such a reference system and moreover contribute to an improved communication of this often emotionally discussed topic (Meyer 2013; Winkel et al. 2005; Scherzinger 1996).

The framework proved suitable in reviewing 79 concepts of different stakeholder groups and across different scale levels. Universal validity with respect to German nature conservation in forests is achieved due to the fact that our analysis is firmly based on the common ground of the CBD and the BNatSchG. The frame may be used to encompass all possible objectives in nature conservation and cultural and natural objectives alike. It may be adopted in various fields of conservation science, despite its presently narrow focus on German forests. Our framework is in line with the initially-mentioned approaches to widely conceive nature conservation (CICES, People and Nature, Nature's Contribution to People). It is, however, constrained to an overall level, requiring further implementation in practice.

The assignment of keywords helps to acquire higher degrees of detail and to overcome the disadvantage of abstraction and is important in specifying COs, making the framework more applicable. Nevertheless, some constraints remain, as further implementation also means setting priorities and identifying synergies or trade-offs between single COs and hierarchical levels. This process, however, defies generalisation, as additional criteria need to be evaluated, such as the local or regional conservation status or the level of protection already gained. Thus, priority setting and the identification of trade-offs are not included in our framework of COs. However, the functional relationships can be regarded as an indication of existing synergies.

Commonalities and differences amongst forest conservation concepts

Our analyses of forest COs show that, in general, there is a broad consensus concerning forest conservation amongst different stakeholders in Germany. A wide variety of targets was found, covering social, biotic and abiotic natural resources. All stakeholder groups emphasised the protection and maintenance of diverse and self-sustaining structures, forest ecosystems, species and natural forest elements. Genetic diversity, landscape elements and abiotic resources are less considered. However, apart from this detected consensus amongst stakeholders and across scales, some differences in prioritising conservation objectives were identified, which do not fully accord with a comprehensive approach to nature conservation. The preamble of the CBD in 1992 already recognised the importance of comprehensive nature conservation concepts in postulating that the contracting parties are "conscious of the intrinsic value of biological diversity and of the ecological, genetic, social, economic, scientific, educational, cultural, recreational and aesthetic values of biological diversity and its components" (United Nations 1992a).

National and international administrations take more account of social demands and the protection of abiotic resources. Since abiotic resources and their regulating services are an essential part of the natural environment (Dewulf et al. 2015), their protection and maintenance is crucial for the sustainable development and use of global biodiversity, including all elements of ecology, economy and society (United Nations 1992b). As the conservation of abiotic natural resources is scarcely mentioned by most stakeholders, conservation efforts in this field could be intensified. For internationally orientated concepts, the percentages found at the third level of COs (climate, soil, water, genes, species, ecosystems and landscape) were more balanced, underlining their more encompassing scope and validity. Although regional stakeholders consider the protection of landscape diversity more than others, COs concerning the protection of landscape and its components were rarely represented. Our results, concerning the under-representation of landscape protection and social-political requirements in the concepts, are in accordance with Petereit et al. (2017), who analysed the implementation of nature conservation in public forests in a manner analogous to ours. Their findings show that the main forest conservation target in concepts was the maintenance of biodiversity in general and that targets for the protection of natural resources were of marginal importance. Securing landscape and recreational values were the least claimed targets.

On the whole, concepts with a wider scale level turned out to be more balanced and consider functional relations. Regional concepts focus on concerns to be tackled by approved forest conservation methods and are more aware of management-dependent systems. Nevertheless, our results demonstrate that there is a lack of focus on the maintenance of culture-bound and management-dependent COs (e.g. cultural heritage and management-related habitat tradition). Even state forestry enterprises focus on natural and self-sustaining ecosystems, although initially we assumed they would pay more attention to management-dependent systems.

For an effective forest biodiversity conservation, it is important to identify synergies and trade-offs (Di Marco et al. 2016; Perrings et al. 2010). Our analyses of biodiversity and forest conservation objectives showed that COs with functions/cross-connections to other levels of COs, while indeed common in some concepts, could be more frequently considered by regional stakeholders. Providing and addressing these synergies is essential for fostering biodiversity protection. Our degree-of-specification analysis within administrative-governmental concepts confirmed the expected increase in specific COs with decreasing scale level for ecosystems only. The weaker response of species and landscape COs can be neglected, as the protection of ecosystem diversity was, with few exceptions, the most common COs in the concepts. Lindenmayer and Franklin (2002) stated that preventing species loss can be achieved by preventing ecosystem loss through maintaining habitat connectivity, landscape heterogeneity and stand structural complexity. Therefore, it seems wise to lay the primary focus on the conservation and restoration of forest ecosystem diversity, which simultaneously contributes to some extent to the protection of species and genetic diversity and serves the purpose of carbon storage in forest ecosystems.

The most frequently mentioned forest conservation keywords (e.g. protecting deadwood in forest ecosystems) reflect topics recently discussed amongst forest conservationists in Germany. The differences between the concepts concerning the frequency of specific keywords are, with few exceptions, not very pronounced, supporting the detected consensus amongst stakeholders in terms of forest conservation.

Knowledge transfer within stakeholder groups and across scales

As ecosystem functions, species and ecosystem processes occur at different temporal and spatial scales (Paloniemi et al. 2012; Peterson et al. 1998), the political and societal challenges are to consider these complex and multi-dimensional processes during governmental decision-making and biodiversity conservation planning (Lee 1993). Our analysis revealed that COs considering societal obligations, e.g. environmental education for effective biodiversity conservation, are under-represented in most concepts, especially surprisingly at the regional level. This imbalance is the more astonishing, as regional stakeholders, in particular, should be aware of what is needed to reconcile the local population with nature conservation. International administrative institutions follow more general nature conservation goals and differ markedly from regional administrations. The challenging transferability of national or regional level CO, on the one hand and broader scales (Europe or worldwide) on the other, can lead to an implementation mismatch.

The detected imbalance in target-consistency prompts us to reject our hypothesis that frameworks of COs within stakeholder groups are scale-independently consensual and confirms rather a slight scale mismatch indicating possibly insufficient transfer and exchange of knowledge. One-to-one transmissions of CO set at the international level may be problematic (Guerrero et al. 2013). The EU Habitats Directive, for example, has a broad spatial range of validity and aims at the conservation of species and habitats of Community concern, many of which are vulnerable. It is implemented at the local or regional level, though, with possible bottom-up consequences (Paloniemi et al. 2012). To overcome trade-offs between aims and targeting inconsistency across scale levels, stakeholders need to stress their conceptual clarity and facilitate an unimpeded transfer and exchange of knowledge.

Conclusions

Paloniemi et al. (2012) put in a nutshell where nature conservation needs to improve on: “analyzing, understanding, and overcoming […] ecological scale-sensitivities requires combining ecological knowledge with information, awareness and experience of actors at various governance levels thus directly bridging science and policy discourses". Furthermore, it requires addressing the importance of protecting all types of ecosystems and their services within nature conservation concepts (Faith 2011; Perrings et al. 2011) as focal species and ecosystems differ in their response towards environmental changes and land-use management intensities at different scales (Nilsson 2009). Our study confirms the importance of integrating the various stakeholders, instruments and scales into conservation practices, taking into account their specific needs and requirements. With the increasing complexity of successfully implementing conservation actions across scales and different stakeholder groups, our framework of COs might qualify as a common basis for conservation priority targeting even beyond the context of German forest conservation and can help to manifest a consensual, precedential and long-term forest conservation.

Our analysis identified shortcomings concerning the unbalanced design of the concepts, where social-cultural demands and societal obligations, as well as the protection of landscape, genetic diversity and abiotic resources are not always covered adequately. These objectives might have been considered as subsidiary COs, implemented per se in the wake of ecosystem and species diversity conservation (umbrella effect). This study suggests to stakeholders that they reassess their conservation concepts in these fields. Improving the awareness of biodiversity and its values is essential to convince residents and other people concerned of the ecological and economic justification and the necessity and consequences of conservation actions.

Forest stakeholder concepts describe the purpose of conservation and restoration measures, such as to secure veteran and habitat trees, forest soil care, management of protected biotopes and species conservation programmes. The next step, specifying how to implement the measures, was taken only in 48 out of 79 concepts which provided information to this effect for certain forest COs. Without practical how-to recommendations, however, even well-founded objectives run the risk of remaining wishful thinking, a long way from implementation.

If, as our results indicate, stakeholders largely agree on the conservation objectives, the question remains why there are still considerable discrepancies in German forest conservation. Implementing forest conservation measures usually involves various stakeholders (owners, inhabitants, users, nature conservationists, administrators) with diverse and sometimes incongruent requirements. Therefore, the procedure of integrating all parties, which is so essential for the successful conservation and sustainable use of forest biodiversity, is to be improved. Mutual respect should be strengthened.

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Supplementary material 1

Tables S1–S3

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Data type: supplementary tables

Explanation note: **Table S1.** Framework for conservation objectives and its application. **Table S2.** List of all target keywords, their German equivalent and their assigned codes according to the framework of conservation objectives. **Table S3**. List of all concepts analyzed in this study with their names, references, type of concept, assigned stakeholder group, jurisdictional scale level allocation and their year of publication.

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