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Policy indicators for use in impact evaluations of protected area networks

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ABSTRACT

The number of protected areas (PAs) has steadily increased in the past 20 years, but their effectiveness to meet conservation targets is consistently questioned. Most conservation impact evaluations of protected areas assume that formal designations, like that of IUCN categories, reflect site-specific conservation rules, but this is not always true. In this paper we illustrate how conservation rules could be empirically assessed by use of content analysis combined with optimal scaling. This flexible methodology allows us to quantitatively assess strictness levels for use in conservation impact evaluations. The strictness measures could also indicate whether conservation rules are consistently applied in the different IUCN categories thereby providing guidance for future assignment of PAs to the IUCN protected area management categories. We illustrate how policy indicators based on conservation rules could be developed in two contrasting mountain protected area networks in Norway and in British Columbia (BC), including a total of 48 PAs in Norway and 51 in BC. Conservation rules for recreational use, motorized access and resource use were quantitatively assessed, thus providing a measure of how strictly PAs regulate the different human activities. Our results show that the main differences in strictness are between the two countries, followed by the contrast between national parks and provincial parks in BC. Overall, Norway has a more liberal conservation policy than BC and older national parks in BC have a much stricter conservation policy than most of the other PAs in this study. Overarching conservation objectives did not reflect the level of strictness (the conservation rules) that guide the daily management of individual PAs. This applies to both countries. We recommend to empirically investigate site-specific conservation rules to include *de facto* management of human activities in conservation policy impact evaluations. The methodology is also useful for monitoring downgrading of the protected area status, which is a result of authorizing human activities that are not consistent with conservation objectives.

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1. Introduction

Protected areas (PAs) have long been the cornerstone for preserving biodiversity, ecosystem services and other global environmental benefits (Chape et al., 2005). Despite the increase in numbers and coverage of PAs, the world's biodiversity and other ecosystem services continue to decline, also within park boundaries (Geldmann et al., 2013; MacKinnon et al., 2015; Pressey et al., 2015). The 10th Conference of the Parties (COP) to the Convention on Biological Diversity (CBD) adopted a new Strategic Plan for Biodiversity 2011–2020 including what is commonly known as the 20 Aichi targets. Aichi target 11 states:

"*By 2020, at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes*" (CBD, 2010).

Aichi target 11 acknowledges that area coverage is not sufficient for halting biodiversity declines. Many of the world's PAs offer weak protection against the human activities that cause the declines of biodiversity and ecosystem services (Leverington et al., 2010; Watson et al., 2014). There is therefore a growing awareness of the need to invest more in the design and management of protected area networks.

A key question that has surfaced in global impact evaluations of PAs is whether strict versus multiple use PAs are more effective at protecting biodiversity and ecosystem services (Ferraro et al.,

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2013; Nolte et al., 2013). Strictly protected areas that permit few extractive uses and where access is limited have long been argued as necessary for achieving conservation targets (e.g. Hilborn et al., 2006; Locke and Dearden, 2005; Terborgh, 2004). Others maintain that more inclusionary approaches like community-based conservation that allow sustainable use in PAs could be more effective at meeting both conservation and development objectives (e.g. Berkes, 2004; Nelson and Chomitz, 2011; Tallis et al., 2008). The proponents of multiple use PAs argue that less strict protected areas could reduce conflict levels, increase compliance and lower the costs of overall enforcement. Permitting sustainable uses in PAs could also leverage local support for protection against large-scale development interests such as logging, mining and oil extraction (Ferraro et al., 2013; Naughton-Treves et al., 2005; Nolte et al., 2013).

Most protected area evaluations use the six management categories developed by the International Union for Conservation of Nature to distinguish between strict versus multiple use PAs (IUCN; e.g. Ferraro et al., 2013; Joppa and Pfaff, 2011; Nolte et al., 2013). Strict protection falls under the IUCN categories I–IV, which prioritize biodiversity conservation over use. IUCN categories V and VI are less strictly protected multiple use areas and cultural landscapes shaped by human disturbance over time (Dudley, 2008). A number of researchers have questioned the use of IUCN categories as a measure of strictness as they were not originally designed for that purpose (Dudley et al., 2010). The concerns have been underscored by recent publications which show no clear correspondence between the IUCN designations and their level of protection (e.g. Joppa et al., 2008; Leroux et al., 2010; Muñoz and Hausner, 2013). Ferraro et al. (2013) distinguish between *de jure* protected area rules – legal regulations, and *de facto* management—management in practice, for evaluating strictness levels in PAs. Indeed PAs could be strictly protected through legislation, but poorly enforced, or *vice versa*, weakly regulated but strictly managed (Chhatre and Agrawal, 2008). Ostrom et al. (1994) also distinguishes between legal rules, rules-in-use and practice to explain management outcomes. The conservation rules in protected area networks are a product of decision-making and negotiation at different levels of organization. To truly include strictness level in impact evaluations we need to examine how protected areas are assigned to the IUCN categories, and how rules have been adjusted to the specific condition in the individual PAs (Hirschnitz-Garbers and Stoll-Kleemann, 2011).

In this paper we first elaborate why we need to consider site-specific conservation rules in conservation impact evaluations. Secondly, we illustrate how policy indicators based on conservation rules could be evaluated in two protected area networks—one in Norway and one in British Columbia, by use of content analysis, optimal scaling and data visualization tools. We analyze the consistency of conservation rules for the different IUCN categories across countries/regions and PA age and size. Finally, we discuss how policy indicators of site-specific conservation rules could be used in conservation impact evaluations.

1.1. Conservation rules in protected areas

Human activities in protected areas are regulated by rules which are "*generally agreed-upon and enforced prescriptions that require, forbid, or permit specific actions*" (Ostrom, 1986). Conservation rules for each individual PA are not necessarily the same as formal legal rules that are usually decided upon at a higher level of decision making (Ostrom et al., 1994). Conservation rules depend on how decision makers understand, translate and enforce rules in each individual PA. They are influenced by norms and practices specific to stakeholders and the managers of the PAs. Recent studies have shown how international conservation policies influence domestic legislation and management models differently depending on national norms and practices (Fauchald et al., 2014; Hongslo et al., 2015). Pressey et al. (2015) refer to the "the tyranny of small decisions" to describe how decisions on different levels result in poor alignment between policies, management and conservation impacts. For example, conservation planning has suffered from the establishment of protected areas in remote locations where there are no real threats to biological diversity (Joppa and Pfaff, 2009; Tsianou et al., 2013). At the site level, Coad et al. (2015) argue that global protected area evaluations need to go beyond the area-based target set in Aichi Target 11 to also include measures of effective planning and management of protected areas. The quality of protected area management rather than formal designations decides how well protected areas perform. Furthermore, the increased multi-linkage nature of conservation, where power is dispersed over several levels of management with stakeholders participating at the various steps of rule-making (see Berkes, 2004; Dearden et al., 2005), is likely to create a mosaic of PAs with different conservation rules which must be evaluated empirically.

Conservation rules are usually reflected in the management plan which operationalizes and adjusts laws and policies made at higher levels to the specific sites (Eagles et al., 2014). A management plan is defined as a "*document that sets out the management approach and goals, together with the framework for decision making, that should be applied in the protected area over a given period of time*" (Thomas and Middelton, 2003). The management plan should support daily decision making by compiling all policies that apply to the specific PAs, including clearly defined overarching goals and site-specific rules (Eagles et al., 2014). Ideally, the management plan should describe any laws, norms and agreements that define the conservation rules in the park. Clearly stated management objectives, and the type and extent of the human activities allowed, are considered crucial for effective management.

Eagles et al. (2014) showed that the plan quality for visitor management for different categories of PAs differed substantially in Ontario Provincial Parks, with some PAs having less detailed plans for management than others, and some plans not even mentioning the uses and the level of use allowed in the park. They also found weak policy coherence between site-level and provincial level policies. Similarly, Muñoz and Hausner (2013) found alpine PAs in Spain to have vague goals for prioritizing biological diversity. Conservation rules were dependent on the specific autonomous regions and showed limited correspondence with national policies or IUCN categories. In this study, less than 50% of the PAs had a management plan. Similar results have also been found for other protected areas in Spain (Rodríguez-Rodríguez and Martínez-Vega, 2013), Greece (Vokou et al., 2014) and other European countries (Stoll-Kleemann, 2010). Given the lack of coherence with both national and international policies, and the strong regional influence of site-specific management of PAs, it is crucial to evaluate conservation rules before evaluating how protected areas perform.

There seems to be a discrepancy between formulations of objectives and conservation rules. For example, wilderness objectives are stated as a primary aim in many European PAs but conservation rules continue to support traditional resource uses such as grazing, mowing, hunting and fishing (Hausner, 2005; Linnell et al., 2015). Tsiafouli et al. (2013) demonstrated that human activities are highly present in the Natura 2000 protected area network in Europe (N = 14 727). As much as 86.5% of the Natura 2000 sites permit agriculture and forestry, 52.7% allow fishing, hunting and gathering, 48.8% of the sites have transportation and communication infrastructure, while 17.6% permit mining and extraction activities. They also found a large variation in permitted human activities depending on norms and practices of the different Member States in the EU. Their study benefited from a publicly available dataset on human activities recorded by experts on each Natura 2000 site. Such databases are generally not available for protected area networks. Thus, a cost-effective alternative for empirical assessment of human activities in protected area networks is content analysis of conservation rules.

2. Methods

The two protected area networks were selected because of the expected high contrast in conservation rules, but low contrast in biophysical conditions, population numbers and human development, in addition to similarities in use and activities accessible to the users of the PAs. Conservation practices in Europe and North America are known to differ with respect to how people and nature interactions are framed and managed (Linnell et al., 2015), and the networks are therefore suitable for illustrating our method. The following steps were taken to measure how strictly human activities are regulated in the two protected area networks:

1. Selection of PA networks.
2. Content analysis of management plans, direction statements or protection regulations for each PA:
   a. Coding of management objectives as defined in the IUCN guidelines (Dudley, 2008)
   b. Coding of conservation rules in ordered categories according to how strictly human activities are regulated.
3. Multivariate analysis of strictness level of conservation rules and their alignment with conservation objectives using optimal scaling.

2.1. Selecting PAs

Our main purpose was to quantitatively assess how strictly activities are regulated. We therefore had to confine our analyses to similar biogeographical regions, otherwise, our analysis would be dominated by differences in use patterns rather than strictness levels per se (e.g. rules for logging are relevant in forested but not in alpine areas). We used the 3rd edition of the British Columbia Ecoregion Classification to identify alpine PAs in BC (Demarchi, 2011), and the Pan-European Landscape Database to select PAs in alpine areas in Norway (Metzger et al., 2005). Only PAs larger than 10 km^2 with more than 50% in the alpine zone that have a management plan or a direction statement were included. Protected areas smaller than 10 km^2 are less likely to vary much with regard to site-specific conservation rules as they are designed for a very specific purpose. Small PAs often also lack management plans.

To include a sufficient number of sites that are protected by federal jurisdiction, we included all the national parks in the mountain range bordering BC, even though some of them were located in Alberta. For simplicity, these are denoted protected areas in BC (Canada_IUCN_II). All the provincial parks in BC that met the criteria were included (BC _IUCN_I and BC _IUCN_II). Both provincial and national parks in BC are classified as IUCN II. Norway is a unitarian state and only have national level legislation. Approximately 17% of mainland of Norway is protected, and this is dominated by national parks (9.7%) and protected landscapes (5.4%; Environment.no, 2016). To avoid a very low sample of PAs for a given IUCN category we did not include IUCN categories represented by fewer than three PAs.

2.2. content analysis

Content analysis was used to quantitatively assess the level of strictness of the conservation rules and how these align with the overarching objectives relating to national and IUCN designations. The text from management plans/direction statements and protection regulations was coded deductively using prior coding schemes (Morgan, 1993). A quantitative approach using prior codes was appropriate for our analysis since we primarily coded manifest content which was easily interpreted from the documents (e.g. an activity was permitted or not). We used the IUCN guidelines for protected area management (Dudley, 2008) to define objectives in the coding scheme. For some of the conservation objectives we had to revise our prior codes and develop coding schemes iteratively as the targets set in the protected areas were vague or the wording did not fully correspond to the definitions in the IUCN guidelines (see below and Table 1). We focused on public access and consumptive resource uses, which in the conservation literature is assumed to leverage support for protection against larger-scale development such as mineral extraction, commercial tourism and property development (Durán et al., 2013; Nolte and Agrawal, 2013). These activities are also more open for value judgement at site-level, and we therefore expected conservation rules to vary more depending on site-specific norms and conservation practices.

2.2.1. a) Coding schemes for conservation objectives

Conservation objectives are fundamental to the classification of the IUCN categories, and we therefore expected to observe a covariance between the objectives and the level of strictness for different types of activities. We made a list over overarching management objectives following IUCN categories (Dudley, 2008), which consisted of eight objectives; *species, connectivity, biodiversity, wilderness, recreation, heritage, cultural landscape*, and *sustainable use* (see Table 1a). We coded the presence of these objectives in the management plans and/or direction statements. Wilderness is a concept that is rarely used in Norway, but national parks are usually established to "protect large and relatively untouched areas", which we coded as the presence of a *wilderness* objective. We coded the objective *biodiversity* for PAs preserving ecosystems or biodiversity in general, including representative ecosystems, ecosystem functions, and ecological integrity. This objective is the primary objective of IUCN Ia and II, but should also be present in the other IUCN categories. We decided to separate the conservation of specific species and their habitats (*species* objective) from the broader concepts of biodiversity protection and ecosystem conservation. To protect particular species or habitats of international, national or local concern is the main characteristic of strict nature reserves (IUCN Ia) and habitat/species management areas (IUCN IV). Establishing networks of PAs for the protection of wide-ranging and migratory species has been strongly emphasised in later years (Woodley et al., 2012). We therefore coded *connectivity* specifically. Objectives that mention the need to connect to other PAs or to create buffer zones to protect wide-ranging and migratory species were coded as *connectivity*. The *heritage* objective was coded as present when conserving historically important values and features typical of natural monuments (IUCN III) were mentioned as an overall objective (e.g. geological features, archeological remains, sacred sites, and historic sites). *Cultural landscape* includes protection of traditional management practices for preserving characteristic landscape values typical of IUCN V, and *sustainable use* refers to sustainable management of resources, an objective usually included in indigenous use areas (IUCN VI).

2.2.2. Coding schemes for conservation rules (public access and consumptive uses)

We first scanned the management plans/direction statements to identify the human activities that were considered important for managing PAs in the alpine regions. We found three sets of conservation rules we deemed applicable for this cross-national analysis i.e. that are comparable within and between the PA networks, namely consumptive resource use, motorized-vehicle use and recreational use (Table 1b). 1. Consumptive resource use includes regulations of consumptive resource use such as hunt-

Table 1
Coding scheme of a) conservation objectives as stated in the IUCN guidelines for protected area management (Dudley, 2008), b) conservation rules for resource use, recreation and motorized access and c) predictors potentially explaining differences in site-specific conservation rules.

a) Objectives	Coding scheme (Yes/No)
Species	To protect specific flora and fauna species and their habitats
Connectivity	To protect connectivity for wide-ranging and/or migratory species that cannot be conserved entirely within a single protected area.
Biodiversity	To protect natural biodiversity along with its underlying ecological structure and supporting environmental processes
Wilderness	To protect large unmodified or slightly modified areas, retaining their natural character and influence.
Recreation	To provide environmentally and culturally compatible recreation and/or education opportunities
Heritage	To protect natural – or cultural sites that are of historical importance, incl. spiritual and cultural values.
Cultural Landscape	To protect and sustain important landscapes and the associated nature conservation and other values created by interactions with humans through traditional management practices
Sustainable Use	To promote sustainable use of natural resources, considering ecological, economic and social dimensions; usually aims to protect traditional local and indigenous livelihoods.
b) Rules	**Coding scheme (0 = not allowed, 1 = permits, 2 = restrictions and 3 = allowed)**
Consumptive resource use	Rules for consumptive resource uses refers to non-commercial harvest of resources such as *hunting, fishing, trapping, collecting of berries, mushrooms, herbs and other plant materials, cutting firewood* and *livestock grazing*. Non-renewable resources or the equipment used to harvest resources were not included here.
Recreational use	Rules for non-consumptive and small-scale recreational use in the PAs, including the possibility to make and collect firewood for campfires, tenting, horse-riding, biking, dogs. Access by foot or ski has not been regulated in Norway, and in BC there are also few restrictions. We therefore excluded rules for access by foot or ski from the analysis.
Motorized access	Rules for motorized access to PAs. *Powerboat* = motorized vessel for travelling on water. *Road/ATV* = access by road or motorized vehicles intended for use off public roadways during the snow-free season. *Snowmobiling* = motorized vehicles used for travelling on snow. *Air* = access by helicopters or fixed-wing aircrafts. *Heli-sports* = skiing or hiking assisted by helicopter or aircrafts (not only transport).
c) Predictors	
Country/region	Are conservation rules predicted by the differences between countries/regions (i.e. BC and Norway)?
IUCN categories	Are conservation rules predicted by the strictness levels as indicated by IUCN categories?
Size (km^2)	Do rules differ depending on the size of the PAs? E.g. Do larger PAs allow multiple uses?
Year established	Are rules in older PAs more strict than more recently established PAs?

ing, fishing, trapping, collecting, cutting firewood and livestock grazing; 2. Motorized use includes restrictions on all-terrain vehicles (ATV)/cars, snowmobiles, helicopters, –and other means of aerial transportation and powerboats; 3. Recreational use includes restrictions on camping, campfires, collection of firewood for camping, horseback riding, and biking. The strictness level for these conservation rules was coded in four ordinal levels:

0 = Not allowed
1 = Activities regulated by permits
2 = Spatial or time-limited restrictions of activities
3 = Allowed

While these levels could be nuanced, for instance by adding another level for multi-year permits and licenses, and by separating spatial –and time-limited restrictions, we decided to keep it simple to avoid too many categories for analyzing a relatively limited set of PAs. The classification of conservation rules was particularly simple in BC, as the management plans usually included a table in the end providing an overview over the strictness level for the different human activities. In addition to the four levels already mentioned, namely not allowed, permits, spatial –and time-limitation and allowed, BC plans include the category "normally not allowed but the activity is present and is allowed to continue". We code these cases as permits. A similar practice occurs in Norwegian PAs where the relatively numerous right-holders, particularly connected to sheep and reindeer husbandry, cabins, and local hunting and fishing facilities are given more elaborated user privileges (their activities are allowed to continue as exceptions to the general prohibitions) than regular visitors.

Indigenous uses, commercial tourism and mining were left out of the analysis. Instead, we provide descriptive statistics of the portion of PAs in our sample that have such uses/restrictions of use (Table 2c). Large-scale encroachments like extractive activities, industrial-, residential- and second-home development inside PAs are often relatively few in number, but tend to involve a substantial case administration (environmental impact assessments, zoning plans etc.). A case study approach that analyze decision-making in the few PAs where such activities occur is more suitable than mapping conservation rules for entire networks.

Commercial tourism such as permits for tourist businesses and visitor facilities is managed quite differently in BC and in Norway. In BC, trade-offs between potentially conflicting objectives, such as between tourism use and conservation values, are managed by zoning (Thede et al., 2014). Visitor facilities are usually present in the front country in BC. It is defined as one kilometre on either side of the park road or a highway, and offers developed campsites, tourist –and recreation facilities. Front country tourism, including the collection of fees, has been devolved to private companies who provide tourist facilities and activities (i.e. public and for-profit model; Eagles et al., 2012). Zones for backcountry recreation are mostly intended for backpacking and wilderness experiences. In Norway, the public right of access allows everyone the right to hike, fish, bathe, ski, camp, pick berries etc., even on privately owned land (Kaltenborn et al., 2001). Fees can be collected for driving on roads, but not for entrance. Visitor facilities are usually placed outside the PA boundaries, and most of the PAs are mainly accessible by foot or ski, with backcountry cabins available for overnight stays (Table 2b).

Indigenous uses by Sami in Norway and by First Nations are generally allowed in the form of traditional hunting, fishing, pasture and campgrounds, and a different set of coding (or method) is needed to capture more subtle differences in indigenous resource rights between the two regions.

2.3. Gifi system for optimal scaling

The coding of conservation rules provided a dataset with ordinal strictness levels that are nonnumeric and nonlinear in character. Correspondence Analysis on Instrumental Variables (CAiv) has previously been used to explain the policy differences among autonomous regions in alpine areas in Spain (Muñoz and Hausner,

Table 2
Descriptive statistics of a) the number of PAs categorized by management objectives (IUCN classification) and the median age and average size for these groups of PAs b) the percentage of parks with visitor facilities and car access within a 5 km buffer zone from park borders and tent camps in the backcountry c) the percentage of PAs with ongoing mining activities inside PA borders, with restrictions on commercial tourism (guided tours etc. not facilities), that accommodates indigenous use rights and with on-foot restrictions with the objective to protect conservation qualities.

		British Columbia			Norway	
		BC IUCN I	*BC_ IUCN II*	*Canada_ IUCN II*	*IUCN II*	*IUCN V*
a)	*# Protected areas*	11	33	7	19	29
	Median Age	1980	1970	1901	1990	1997
	Average size km²	1709.9	1140.9	2621.5	1134.5	324.3
b)	*% Car access*	81.8	84.8	100	89.5	93.1
	% Car camping	27.3	36.4	83.3	73.7	55.2
	% Accomodation	18.2	27.3	83.3	73.7	72.4
	% Info center	45.5	42.4	83.3	68.4	58.6
	% Tent camp	54.5	54.5	100	0	0
c)	*% Mining activities*	0	0	0	0	6.9
	% Commercial tourism restrictions	91	87.9	100	57.9	34.5
	% Indigenous use rights	72.7	81.8	28.6	57.9	10.3
	% On-foot access restrictions	0	3	71	5.3	3.4

2013). However, our approach goes further as we used Gifi system for Optimal Scaling (also known as Homogeneity Analysis; Gifi, 1990) that allowed us to preserve the ordinal nature of strictness levels. Optimal scaling has a similar objective as PCA; to reduce a number of variables to fewer dimensions that capture most of the variation in the data. In this case, the resulting dimensions reflected variation in strictness levels. The ordered strictness levels were assigned numerical scores by optimal scaling through an iterative process that selected the main dimensions by the minimization of a least-squares loss function. For ordinal strictness levels the analysis is constrained so that a category will always be less than or equal to the quantification for the category that has a higher rank number in the original data (e.g. Not allowed < Restrictions < Permits <Allowed).

We analysed objectives and rules associated with the three different sets of restrictions, namely consumptive resource use, motorized use and recreational use. IUCN categories, BC vs Norway, size and age were used as supplementary variables to investigate whether the policy differences are associated with these variables. They were not used to define the optimal scaling dimensions. In other words, the strictness scores along the different dimensions in the optimal scaling were only determined by the conservation rules, which were thereafter compared to the explanatory variables. IUCN categories were included since they were expected to represent levels of strictness. Larger PAs could be assumed to have more spatial restrictions (Leroux et al., 2015), while the age of establishment may matter due to the lower weight assigned to human uses for the first PAs established (Palomo et al., 2014).

To select the number of dimensions retained and assess the results of the optimal scaling, we used the classification rates calculated for each variable. Classification rates gave the percentage of observations correctly predicted by the scaling analysis, and we compared those to what would be obtained by a random classification (these will vary from variable to variable depending on the number of categories and proportions in each category). We chose the number of dimensions that represented a trade-off between parsimony and achieving good classification rates. A perfect classification would correspond to categories with no overlap (i.e. a 100% classification rate; de Leeuw and Mair, 2009).

All statistical analyses were performed in the open source software R version 3.2.2 (R Development Core Team, 2016). We used the Kruskal-Wallis H test followed by a multiple pairwise comparison using the Dwass, Steel, Critchlow, Fligner procedure in the NSM3 package to test differences in singular objectives related to formal designations (Schneider et al., 2015). Optimal scaling on rules was carried out in the Homals package (de Leeuw and Mair, 2009). The data visualization tools used to present our results include a two-way boxplot of objectives and a heat map of rules using the R package ggplot2 (Wickham, 2009). We used star plots in the R package ade-4 to connect the scores of protected areas with their category centroid to display results of the optimal scaling.

3. Results

A total of 48 PAs in Norway and 51 in BC met our selection criteria. BC has mainly used the two strictest categories (BC_IUCN I and II) in the alpine region, whereas Norway has favored the establishment of smaller protected landscapes in later years (IUCNV, Table 2a). National parks (see Canada_IUCN II, Table 2) were established between 1886 and 1920, and truly stand out with regard to a high presence of visitor facilities. Norway also enjoys high levels of access by car and lodgings near or within the PAs. Many PAs in the backcountry of Norway depart from provincial parks in BC as they allow tourist cabins. There are no tent camps in Norway as tenting is integral to the right of public right of access and allowed in most places. Many of the provincial parks and nature reserves in BC are remote and do not have visitor facilities nearby (Table 2b). Commercial tourism that does not involve organized activities (guiding etc.) is generally regulated by permits in most PAs, but organized activities are less frequently restricted the Norwegian protected landscapes. Mining activities within park borders are rare and only occurred in two protected landscapes in Norway. Indigenous uses are accommodated in most PAs in BC and in the PAs in Norway with Sami land use, which is mainly in the north and in the middle part of the country. Restrictions placed on access on foot that potentially could disturb wildlife or damage other protection qualities are mainly limited to the BC national parks (Table 2c).

Protection of *species* and *biodiversity* are stated as objectives for most PAs, and we did not find any significant differences between formal designations associated with these two objectives (Fig. 1). The multiple pairwise comparison of the formal designations (not reported here) showed that it was mostly protected landscapes (IUCNV) that differed significantly in management objectives from the other designations by prioritizing *cultural landscape* rather than *wilderness* and backcountry recreation. *Sustainable use* related to reindeer herding is also a primary conservation objective in some of the national parks in Norway.

In most Norwegian PAs, consumptive resource uses such as hunting, trapping, fishing, grazing, and collection of berries, mushroom and plants are allowed. This stands in stark contrast to the national parks in Canada that do not generally allow consumptive resource use (see Fig. 2). Norway has more liberal conservation rules for camping and for collecting wood for bonfires, and use permits for regulating motorized use. Heli-sport is the only activity

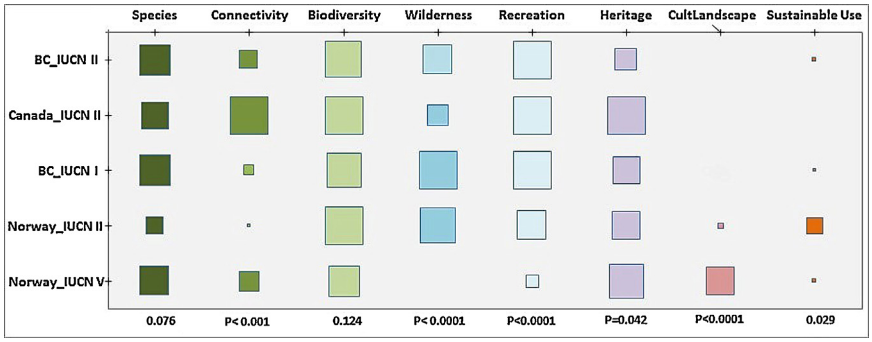

Fig. 1. A two-way barplot showing the percentage of PAs for the given IUCN and country combination where the different management objectives are specified in management plans and/or direction statements. Designations with less than three PAs (e.g. IUCN IV) were not included in this plot. Higher percentages are represented by larger tiles. For example connectivity, biodiversity, recreation and heritage are stated as management objectives in all PAs in Canadian IUCN II and the largest sizes of the tiles are therefore scaled to 100%. Absence of management objectives is represented by no tile at all.

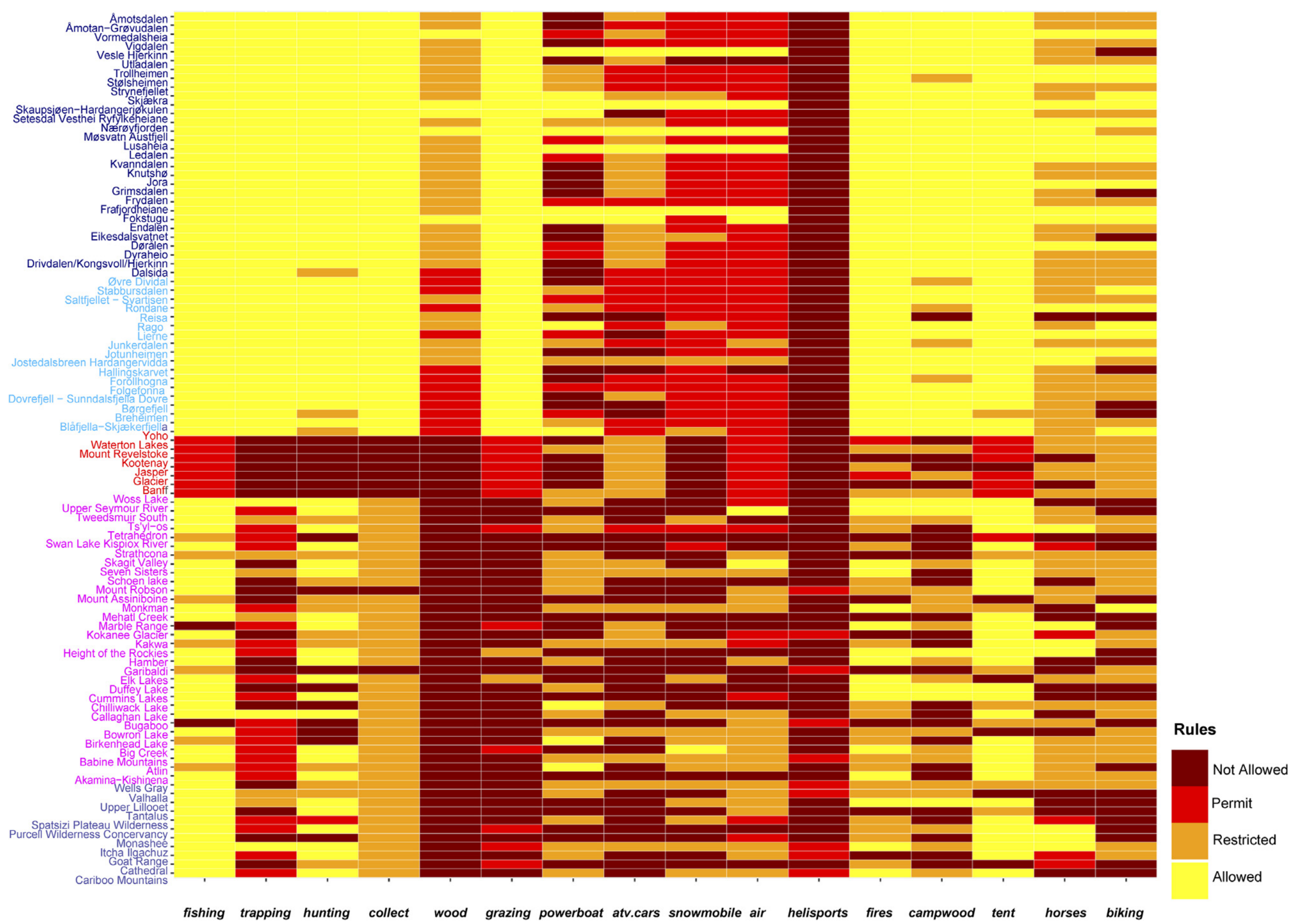

Fig. 2. Heat map illustrating how the different human activities are regulated in the protected area networks. The human activities we compared in the two networks are listed on the X-axis. Darker colours means stricter rules for the associated human activities. Formal designations are represented by different text colours on the Y-axis (Dark blue = Norway IUCN V, Blue = Norway IUCN II, Red = Canadian IUCN II, Pink = BC IUCN II, and Purple = BC IUCN I).

that consistently is more strictly regulated in Norway than in BC. There seemed to be much variation in conservation rules between provincial parks in BC (Fig. 2).

The large contrast in conservation rules between PAs in Norway and BC was also evident using optimal scaling. The two first dimensions of strictness scores obtained by optimal scaling account for most of the variation among PAs (Table 3). The 100% classification rate of BC and Norway using the first two dimensions from the optimal scaling indicated a limited degree of overlap between countries concerning conservation rules. IUCN categories, size and year established did not influence conservation rules as strongly as the contrast between Norway and BC. For example, the IUCN categories did not explain more than the random classification along the first two dimensions (42 as compared to 44 by random classification), but increased marginally to a classification rate of 58% by adding a 3rd dimension. Dimension 3 was strongly associated with conservation objectives stated in the plans (i.e. biodiversity, wilderness, recreation and cultural landscapes), but not as much with the conservation rules (with the exception of access by air and snowmobiles). A small set of protected

Table 3
Classification rates (CR) giving the percentage of observations that are correctly predicted as a function of the number of axes retained in the optimal scaling analysis. Classification rates were compared to the random classification which depends on number of categories and their proportion (e.g. "Country" has two categories, Norway and BC, each representing 50% of the protected areas). The shaded areas visualize a substantial increase in classification rates from the random CR to 2 (% CR2) and further from 2 to 3 (% CR3) and 3- 4 (% CR4) dimensions. The non-active variables did not define the dimensions, but their classification rate allows us to check the correspondence with aims and strictness levels.

Variable	Random CR	% CR (2)	% CR (3)	% CR (4)
wilderness	52	69	84	85
biodiversity	87	54	90	89
species	62	55	54	58
sustainable use	72	58	64	63
backcounty recreation	64	75	88	86
heritage	64	67	67	78
cultural landscape	64	76	89	89
connectivity	51	69	68	68
fishing	70	64	65	76
trapping	36	77	76	74
hunting	51	64	63	65
collecting	42	98	98	98
firewood extraction	38	85	90	89
livestock grazing	39	85	82	78
powerboats	33	31	44	62
atv_cars	33	60	68	71
snowmobiles	31	58	74	84
air	36	39	78	80
helisports	82	68	68	71
campfires	48	70	69	76
campfirewood	37	69	73	77
horseriding	37	31	53	65
biking	38	52	59	71
dogs	41	74	78	90
camping	62	63	64	62
NON-ACTIVE				
BC/Norway	50	100	100	100
IUCN	44	42	58	62
size	33	40	44	46
year established	33	62	64	62

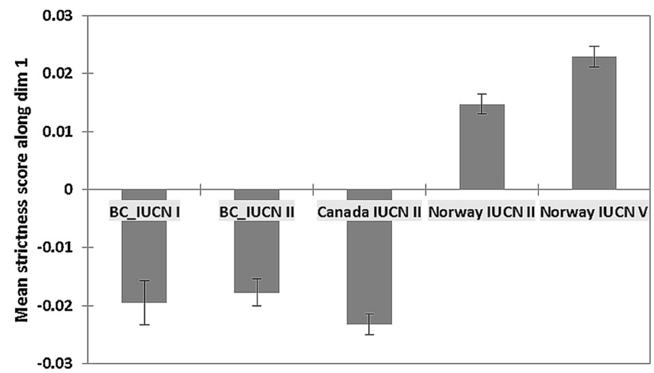

Fig. 3. Strictness scores for the formal designations on dimension 1 (±SE).

landscapes in Norway (Engdalen, Fokstugu, Ledalen, Møsvatn-Austfjell, Skaupsjøen-Hardangerjøkulen, and Vesle Hjerkinn) that allow motorized use was important for the variation along this dimension.

We plotted the strictness scores along the first dimension to show that the stricter rules, especially for resource use and public access, defines the differences between BC and Norway (Fig. 3). The national parks in BC are more strictly protected than the provincial parks, while the protected landscapes (IUCNV) in Norway allows the most human uses. To further explore differences in specific conservation rules we made a star plot of the first two dimensions, which shows that the Norway and BC sets of PAs are not overlapping (Fig. 4). The Norway set corresponds to the right hand side of all figures showing that many activities are allowed in the PAs (Lighter colours, Allowed = 3). The star plot shows that the protected area network in Norway has more liberal rules with regard to most human activities with the exception of heli-sport. The second dimension differentiates among the national parks that were established early (i.e., age of parks matters) and the provincial parks in BC. Canadian national parks are generally stricter and are more targeted towards connectivity among PAs. There is a high overlap between BC IUCN I and II and IUCN II and V, indicating that IUCN categories do not matter much for conservation rules.

4. Discussion

We have demonstrated how conservation rules could be investigated for entire protected area networks by content analysis, optimal scaling, and data visualization tools in 51 PAs in BC and 48 in Norway. Our quantitative assessment supports the study of Linnell et al. (2015) suggesting that European protected areas are more aligned with the "people and nature" view than the "nature for itself" view promoted in the Yellowstone model (see also Mace, 2014). Many recent studies that analyze conservation effectiveness assume that stricter rules apply for IUCN categories I and II or national designations (Ferraro et al., 2013; Joppa et al., 2008; Leroux et al., 2010; Nolte et al., 2013), but we show that conservation rules that guide the daily, site-specific management, do not necessarily meet such expectations. The main difference in conservation rules is associated with the different norms and practices between BC and Norway, and between the national parks and provincial parks in BC. Conservation objectives correspond to IUCN categories, but the conservation rules do not reflect these formal designations.

We were mainly motivated by the recent call for empirical evaluation of policy impacts on biological diversity (Baylis et al., 2015; Pressey et al., 2015). A recurring topic in the conservation literature is the impact of strict protectionism versus multiple use protected areas on ecological and social outcomes (e.g. Ferraro et al., 2013; Nolte et al., 2013). Allowing small-scale uses is expected to increase

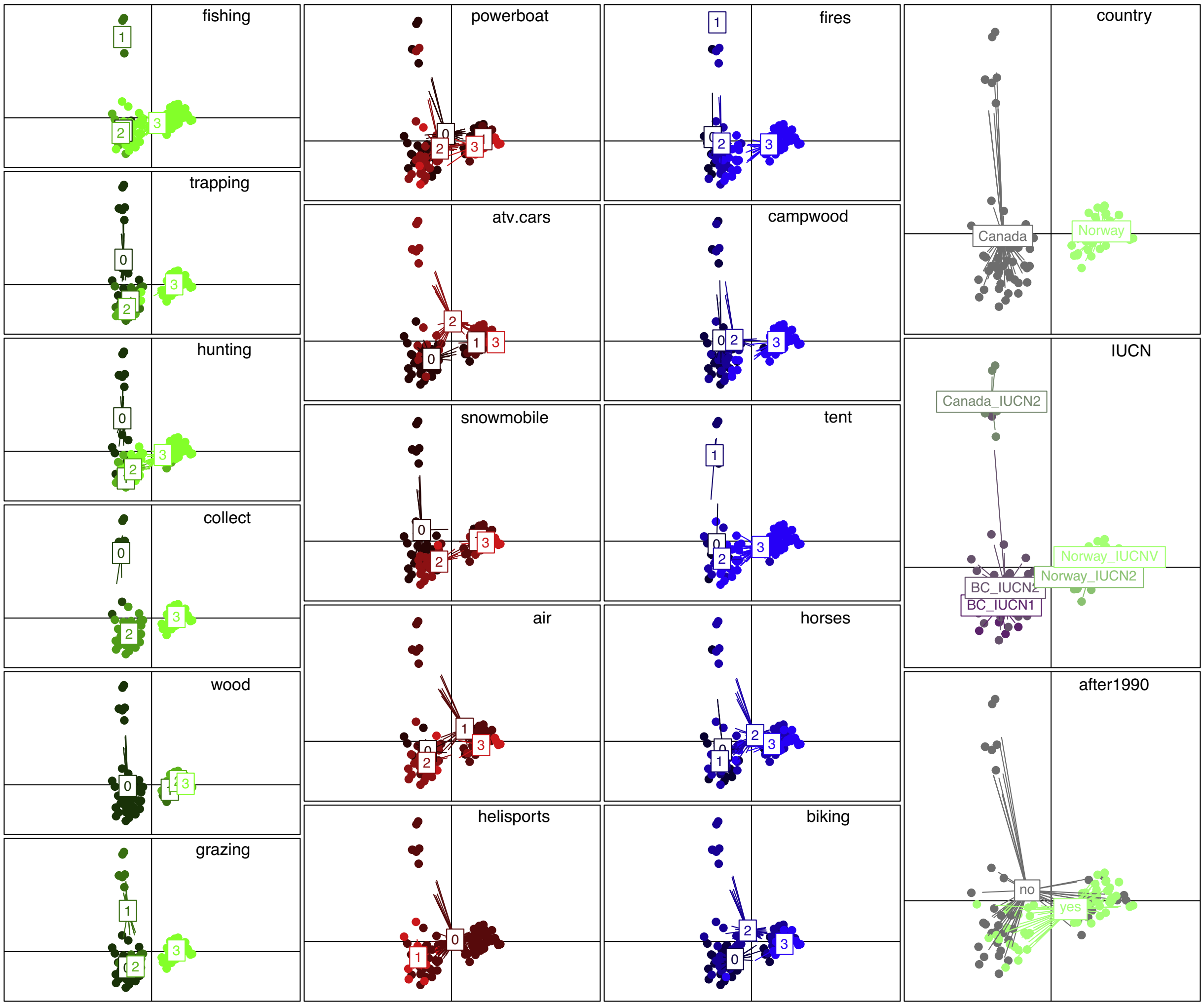

Fig. 4. Star plots of the numerical scores of the first two dimensions obtained by optimal scaling. Larger distances between scores reflect greater differences in rules. The row furthest to the right shows no overlap in scores between BC and Norway along the first dimension. On the second dimension there is a contrast between the federal IUCN II categories (Canada IUCN II) and the provincial parks (BC_IUCN I and II). The strictness levels of rules corresponding to these differences are plotted on the first three rows to the left (0 = Not allowed, 1 = Permits, 2 = Restrictions, 3 = Allowed); resource use (Green), motorized use (Red) and recreational use (Blue).

the support for conservation, thereby preventing large scale development, deforestation, and extractive industries that potentially have much higher impacts on conservation values. Analyzing conservation rules provides a measure of degree of protectionism originating from *de facto* management, knowledge that can be used in combination with remote sensing and variance matching to assess whether avoided land use changes can be attributed to conservation (Andam et al., 2008; Hutton et al., 2005; Nelson and Chomitz, 2011). The policy indicators could be directly linked to habitat loss and species trends to analyze *why* biodiversity is declining within protected areas borders (Geldmann et al., 2013), for example by linking retrospective policy analyses to population trends (Di Marco et al., 2014; Hausner et al., 2011).

We developed this study with the strict protectionism and the resource utilization hypotheses in mind, but the multivariate analysis could also inform governments as they assign PAs to the different IUCN categories. The IUCN classification system is supposed to be a universal classification system, with higher levels (I–IV) allowing less use than the lower categories (V, VI), but as evident from our results, this is not necessarily true. It is well known that country-specific conservation norms influences how protected areas are managed and understood (Fauchald et al., 2014; Hongslo et al., 2015), and as expected the conservation rules reflect the right of public access and the subsistence harvest culture in Norway, while wilderness norms dominate in BC. Optimal scaling of conservation rules also map the deviations from country-specific patterns, and identifies the PAs that do or do not meet the national- and international standards for PA categories. For example, protected areas in the IUCN category Ib are expected to protect ecosystems of high degree of intactness and encourage simple, quiet and nonintrusive use (Dudley, 2008). Motorized access should preferably be absent or highly restricted, but motorized recreational activities such as snowmobiling and heli-sports are present in about half of the PAs interpreted as IUCN category 1b in BC.

As protected area coverage has expanded the last decades, so has the diversity of objectives that need to be fulfilled, making it unclear to what extent biodiversity conservation is prioritised (MacKinnon et al., 2015; Watson et al., 2014). Recent evidence shows that downgrading, defined as “the legal authorization of an increase in the number, magnitude, or extent of human activities in protected areas” is a widespread phenomenon (Mascia and Pailler, 2011). A continuing trend towards multilevel management that involves a diverse set of stakeholders in the different steps of rule-making will most likely result in a larger variation of conservation objectives and rules in PAs. It is therefore important to develop conservation tools that could monitor downgrading (or upgrading) of protected area status and permitted uses at site level. Crowdsourcing tools such as the PADDD tracker (http://www.padddtracker.

org/) is one option, but one that is highly dependent on the voluntary contributions of downgrading events to the web site. Empirical assessment of conservation rules offers a systematic tool for evaluating entire protected area networks, which could be directly used in conservation planning. For example, the strictness measures of PAs could be overlaid maps of vulnerable areas and biodiversity hotspots to evaluate whether these areas are sufficently protected against high-impact human activities.

4.1. Limitations and further improvement of policy indicators for use in protected area impact evaluations

Over the past decades, there has been a growing demand for composite indicators to link science with management or policy (Lund et al., 2009). These indices aggregate numerous variables into a single metric to e.g. rank environmental performance of different countries (Bondarchik et al., 2016), monitor the conservation status of ecosystems (Stephens et al., 2015; Yoccoz et al., 2001), or assess the protected area management effectiveness at individual PAs (Hockings et al., 2004). Our work must be seen as first step towards building a composite indicator that could reflect conservation policy practices in multiple protected area networks for the purpose of impact evaluations.

Prior to the development of composite indicators, it is important to carefully select indicators according to a theoretical framework and statistically determine the structure of the data set (Dobbie and Dail, 2013). The choice of indicators in our case was guided by theory suggesting that small scale uses and physical access to protected areas will benefit conservation in the long run. The three sets of indicators reflecting consumptive resource use, motorized access and recreation were selected through an iterative process where the purpose was to include all variables that were comparable in the two protected area networks. By use of optimal scaling we found that the 16 policy indicators displayed similar strictness patterns, which means that a singular composite policy indicator could be used for comparing the two countries. Adding protected area networks from other countries could potentially reveal more complex patterns. We asssumed equal weights of the different policy indicators, discounting the fact that some human activities may pose larger threats to conservation status than others. Often such weights are assigned by experts such as in the System for the Integrated Assessment of Protected Areas (SIAPA; Rodríguez-Rodríguez and Martínez-Vega, 2012). Adding weights based on conservation threats is complicated given the non-linear behaviour that such indicators may exhibit (e.g. a low-level of grazing may support the objectives, but too high densities of livestock could undermine the conservation values). As there are no universally acceptable ways of assigning weights depending on conservation threats, an empirical, data-driven approach seems appropriate (Dobbie and Dail, 2013; Paruolo et al., 2013). Multivariate analyzis, such as optimal scaling, is a relatively objective way to select weights for uncovering the relative importance of the policy indicators, and to reflect the underlying data structure for the appropriate use of composite indicators (i.e which policy indicators respond similarly to explanatory variables; Rodríguez-Rodríguez and Martínez-Vega, 2012).

This methodology could easily be adapted to other ecoregions or policy-relevant questions. In any case, the policy indicators selected for cross-national analysis need to be comparable. For example, a complete policy analysis of conservation practices in the protected areas networks in Norway and BC suffered from the lack of comparability of mining-and tourism activities. A coding scheme specifically adapted for permit analyses may be more appropriate for large-scale interventions by taking a subset of the network where such activities exist or where there is high demand for resource extraction or tourism.

Another challenge for cross-national analysis is between-country differences in the tools used for regulating human activity. Zoning is used in BC to spatially separate incompatible uses in the PAs (Thede et al., 2014), whereas Norway uses permits to regulate access and use of PAs. To evaluate spatial differences in conservation policy at a finer scale, zones and permits have to be analysed separately and permits should be tied to their spatial location. After assigning rules to spatial locations with the PA boundaries, zones could be analyzed separately, or as in Rodríguez-Rodríguez and Martínez-Vega, (2012), greater weights could be assigned to core conservation zones compared with transition – and buffer zones before providing a singular value.

Finally, we could do more to analyze the strictness scores from the optimal scaling. We could include other predictors that can explain further the variation in conservation rules at the site-level, such as population density, accessibility, or degree of involvment of user groups in management. Explaining why site-specific rules have been assigned could also help us understand how the different countries interpret the IUCN classification system.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.ecolind.2016.12.026.

The supplementary material includes the raw data from the content analysis of conservation objectives and strictness levels coded for 48 parks in Norway and the 51 parks in BC and the r-script for optimal scaling (Appendix A). The authors are solely responsible for the content and functionality of this material. Queries (other than absence of the material) should be directed to the corresponding author.

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