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A Quantitative Analysis of Biodiversity and the Recreational Value of Potential National Parks in Denmark

Frank Wugt Larsen · Anders Højgård Petersen · Niels Strange · Mette Palitzsch Lund · Carsten Rahbek

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Abstract Denmark has committed itself to the European 2010 target to halt the loss of biodiversity. Currently, Denmark is in the process of designating larger areas as national parks, and 7 areas (of a possible 32 larger nature areas) have been selected for pilot projects to test the feasibility of establishing national parks. In this article, we first evaluate the effectiveness of the a priori network of national parks proposed through expert and political consensus versus a network chosen specifically for biodiversity through quantitative analysis. Second, we analyze the potential synergy between preserving biodiversity in terms of species representation and recreational values in selecting a network of national parks. We use the actual distribution of 973 species within these 32 areas and 4 quantitative measures of recreational value. Our results show that the 7 pilot project areas are not significantly more effective in representing species than expected by chance and that considerably more efficient networks can be selected. Moreover, it is possible to select more-effective networks of areas that combine high representation of species with high ranking in terms of recreational values. Therefore, our findings suggest possible synergies between outdoor recreation and biodiversity conservation when selecting networks of national parks. Overall, this Danish case illustrates that data-driven analysis can not only provide valuable information to guide the decision-making process of designating national parks, but it can also be a means to identify solutions that simultaneously fulfill several goals (biodiversity preservation and recreational values).

Keywords Biodiversity · Denmark · Ecosystem service · National parks · Recreational value · Systematic conservation planning

F. W. Larsen (✉) · A. H. Petersen · M. P. Lund · C. Rahbek
Center for Macroecology, Institute of Biology, University of Copenhagen, DK-2100 Copenhagen Ø, Denmark
e-mail: fwlarsen@bio.ku.dk

N. Strange
Forest & Landscape, University of Copenhagen, DK-1958, Frederiksberg C, Denmark

Introduction

The variety of living organisms on Earth is decreasing. The current rate of species extinction is estimated to be 100 to 1,000 times the natural background rate, and this rate is expected to increase if no preventative action is taken (Pimm and others 1995, Millennium Ecosystem Assessment 2005). At the 2002 Johannesburg World Summit on Sustainable Development, 190 countries committed themselves to achieve, by 2010, significant reduction of the current rate of loss of biologic diversity at the global, regional, and national levels (United Nations Environment Programme 2002). The European Union (EU) has committed itself to the more ambitious target of actually halting the loss of biodiversity by 2010. Denmark has implemented this goal as the overall primary objective of the governmental Action Plan for Biodiversity and Nature Conservation in Denmark 2004–2009 (The Danish Government 2004). In Denmark, the protected areas of the Natura 2000 network receive most attention. So far these areas constitute 254 habitat areas (European Economic Community [EEC] 1992) and 113 bird-protection areas (EEC 1979) for the terrestrial and marine environments. In total, the land areas comprise 3,591 km^2, which is equivalent to 8.3% of the total land area (Danish Agency for Spatial and Environmental Planning 2008). Furthermore, specific habitat types are under general protection, whereas certain areas are under special conservation regulations (Danish Agency for Spatial and Environmental Planning 2008).

However, these areas are relatively small, e.g., the average size of the EU habitat areas, excluding marine areas, is 9.6 km^2 (SD = 16.5 km^2, n = 179) (Danish Agency for Spatial and Environmental Planning 2008). Consequently, Denmark is planning to supplement existing efforts with the establishment of larger protected nature areas. These larger protected areas in Denmark are labeled as "national parks" (used hereafter in the article), but they have no direct link to the World Conservation Union (IUCN) definition of the term. Overall, the main objective of establishing national parks in Denmark is to designate large, coherent reserves for the protection and improvement of areas rich in biodiversity, scenic areas, and areas of cultural heritage as well as to improve opportunities for public outdoor recreation (The Danish Government 2004). The establishment of national parks in Denmark should be seen in the context of Denmark being a small country (43,094 km^2) dominated by intensive agriculture and forestry. Seven project areas were launched as "pilot project" areas, meaning that the feasibility of establishing national parks in these areas was explored. The fact that 7 areas were chosen merely reflects political considerations rather than a goal in terms of amount of land designated as national parks. The initial selection of these areas was largely based on consensus judgment among experts and national representatives for governmental and nongovernmental organizations (The Wilhjelm Committee 2001). This was followed by a subsequent bottom-up participatory process selecting areas to satisfy various criteria, in particular, representation of nature types characteristic of Denmark and a high degree of government-owned nature areas (The Wilhjelm Committee 2001). Stakeholders participating in this bottom-up process included counties, municipalities, regional offices of the Danish Agency for Forest and Nature, local interest groups, local businesses and farmers, and local citizens. Legislation and economic support schemes for the national parks were established in May 2007. By 2008, 5 national parks have been designated (Thy, Mols, Skjern Å, Vadehavet and Nordsjælland, see Appendix 1).

Systematic conservation planning (SCP) approaches did not support the selection process, although SCP in the scientific literature is widely recognized as being useful in efficiently guiding the designation of nature areas for biodiversity conservation (Margules & Pressey 2000). Despite the fact that SCP has undergone much progress within the last decade (see Sarkar and others 2006 for overview), only relatively few sets of areas based on data-driven systematic planning analyses have in practice guided the designation of nature reserves, e.g., Australia (Pressey 1998), Papua New Guinea (Faith and others 2001), and South Africa (see Balmford 2003 for overview). Responding to the 2010 biodiversity target requires efficient conservation planning, and here SCP approaches can explore possible synergies among biodiversity and other values, such as ecosystem services, thus identifying networks of areas that fulfill several goals (Faith & Williams 2006). SCP approaches have focused mostly on conservation of biodiversity, whereas, for example, conservation of ecosystem services has received rather little attention because of a lack of data (but see Chan and others 2006). Therefore, little is known about possible trade-offs and synergies between biodiversity conservation and ecosystem services, such as recreational value, when selecting areas for conservation.

Here, we first evaluate the effectiveness of the a priori network of so-called national parks in Denmark proposed through expert and political consensus versus a network chosen specifically for biodiversity and recreation. Second, we analyze the potential synergy between preserving biodiversity in terms of species representation and recreational values in selecting a network of national parks. The analyses are based on the actual distribution of 973 species, which cover a wide variety of taxa. We use four quantitative measures of recreational value to assess whether the goals of biodiversity protection and recreational value of national parks can be combined in the same network of parks.

Methods

As planning units, we used 32 areas representing virtually all larger and relatively coherent nature and seminature areas in Denmark (Fig. 1a). These areas include the 7 suggested official "pilot areas," 17 areas suggested as national parks by two Danish environmental organizations (the Danish Outdoor Council and the Danish Society for Nature Conservation), and 8 areas we identified based on an existing assessment on larger nature areas in Denmark (The Danish Society for Nature Conservation 2004).

The demarcation of these areas overall followed the proposed suggestions from a governmental working group, including nongovernment organizations, and is based entirely on a consensus-driven process (i.e., without any underlying data-driven analysis) (The Wilhjelm Committee 2001). Alternative demarcation of areas, including the merging of some areas, would have been possible. However, because of the attention paid to the suggested areas,

Fig. 1 Map of the 32 potential national parks in Denmark (**a**) highlighting the 7 pilot areas (dark grey), (**b**) highlighting the 10-km UTM grids that were assigned to each of the 32 areas, and (**c**) showing the locations of the 592 nature areas from the survey on recreational values

they will probably (de facto) constitute the candidate areas for national parks. Therefore, we refrained from merging the suggested areas with potential adjacent areas to consider the specific suggested areas in the analysis. The land areas of the planning units covered a range from 35 km^2 to 1,070 km^2 (mean = 273 km^2).

Biodiversity Data

We used distributional data (presence or absence) for various species groups in Denmark. The data included mainly terrestrial species but also some freshwater species. The data included only species that breed in Denmark, and we excluded vagrant, casual, and exotic species from the data set to avoid bias toward those species. The data set constituted a further development of an existing data set that has already been used for quantitative biodiversity analyses in Denmark (Lund 2002, Lund and Rahbek 2002). Because the data were originally compiled for 10 × 10–km Universal Transverse Mercator (UTM) quadrates (= 100 km^2, n = 622), we pooled the data from the quadrates covered by each of the 32 potential national park areas (Fig. 1b). In total, 973 species altogether of the 1,008 species found in the original country-wide data set were covered by the 32 larger areas. The data set covers 5 species of reptiles (Reptilia), 13 species of amphibians (Amphibia), 181 species of birds (Aves), 48 species of mammals (Mammalia), 41 species of dragonflies (Odonata), 23 species of grasshoppers (Orthoptera), 60 species of true bugs (Heteroptera: Pentatomidea, Coreoidea, and Pyrrhocoridea), 21 species of click beetles (Coleoptera: Elateridae), 18 species of crawling water beetles (Coleoptera: Haliplidae), 248 species of hoverflies (Diptera: Syrphidae), 58 species of butterflies (Lepidoptera: Hesperioidea and Papilionoidea), 154 species of large moths

(Lepidoptera: Hepialoidea, Cossoidea, Zygaenoidea, Tineoidea, Yponomentoidea, Bombycoidea, Geometroidea, Sphingoidea, Notodontoidea, and Noctuoidea), 6 species of club mosses (Lycopodiaceae), and 35 species of orchids (Orchidaceae). The data cited include the majority of Danish species within each group. Additional data on selected species of special conservational interest belonging to other groups included 1 fish species (Houting, *Coregonus oxyrhynchus*), 15 beetle species, 9 moth species, 1 mayfly species (Ephemeroptera), 2 stonefly species (Plecoptera), 1 blackfly species (Diptera: Simulidae), 27 flowering plant species (other than orchids), 4 lichen species, and 2 moss species.

We identified threatened species and species listed in European Union Directives (hereafter referred to as EU species) because they receive high conservation attention. We defined threatened species as the "endangered" (E) and "vulnerable" (V) categories of The Danish Red Data Book 1997 (Stoltze & Pihl 1998) for true bugs, crawling water beetles, moths, mammals, flowering plants other than orchids, and various less represented groups. The categories "critically endangered" (CR), "endangered" (EN), and "vulnerable" (VU) of the currently updated Danish Red Data Book (to be published in 2008) were used for dragonflies, grasshoppers, click beetles, hoverflies, butterflies, amphibians, reptiles, birds, and orchids. We defined EU species as the species listed in Annexes II or IV of the Habitats Directive (EEC 1992) and in Annex I of the Birds Directive (EEC 1979). The data set for the 32 areas covers 157 threatened species (of 180 in the original data set) and 70 EU species (of 72 in the original data set).

Recreational Value Data

We used four quantitative measures of recreational value of the 32 potential national parks. In 1996 and 1997, an extensive survey quantitatively assessed visits and activities by people in 592 nature localities (covering approximately 2.010 km^2) in Denmark to assess recreational values (Jensen 2003). The survey included counting parked cars (9,874 individual counts at 2,159 localities) combined with an extensive questionnaire survey (approximately 40,000 completed questionnaires). From the survey we selected the following three quantitative measures of recreational value assessed for each of the 592 nature areas:

1. The number of *visitor hours* per year, which is an estimate of the number of hours spent by people visiting the areas by car, bicycle, or walking. Therefore, this measure simply reflects the total use of the areas by people.
2. The number of *foreign car visit hours*, which is an estimate of the number of hours spent at the areas by foreign, i.e., non-Danish, car visitors. This estimate provides an indication of the recreational value of the areas seen in an international context. However, one should be aware of the potential bias toward sites closer to the Danish border or tourist attractions in Denmark.
3. *Travel distance* is an estimate of the average distance traveled by people visiting the areas on the day of the visits.

To get recreational measures for the 32 potential national parks, we pooled the measures of recreational value from those of the 592 nature localities that were fully or partly located within each of the 32 areas (approximately 33% of the nature localities) (Fig. 1c). For the number of visitor hours per year and the number of foreign car visit hours, we summed the individual values from nature areas within each potential national park. For travel distance, we used the survey area within each potential national park with the highest average travel distance recorded. We chose this procedure to reflect the areas of greatest regional and national interest, rather than locations of mainly local interest, which is in accordance with the official goal of national parks in Denmark.

Although these measures on recreational values are derived from probably the most extensive survey carried out on a national scale, the three measures contain biases. First, they do not cover all important nature areas in Denmark. Consequently, coverage of surveyed nature areas by the 32 potential national parks was uneven (Fig. 1c), and no data were available for 4 of the 32 potential national parks. Therefore, although recreational measures were available for all of the 7 a priori–selected national parks, we discarded 4 areas from the analysis on recreational values. This would pose serious problems if the aim of this study had been to identify an exact set of 7 areas as national parks that could combine biodiversity and recreational value. However, the purpose was to *generally* explore the synergy between biodiversity and recreational value in potential national parks. Therefore, it was possible to explore whether biodiversity and recreational value can be combined in a set of 7 areas among the 28 areas in which we had data on both biodiversity and recreational value.

Finally, the fourth measure of recreational value came from a geographic information system (GIS)–based model estimating "visitor potential" in Denmark in the context of reforestation (Skov-Petersen 2002). The model provides estimates of the number of car-based visits per year per km^2. This measure could potentially bias toward higher visitor potential for sites that are currently nonforested. We visually assigned each of the 32 areas to 5 intervals of visitor potential based on a map showing the model results with a resolution of 1 km^2. See Appendix 1 for the ranking of the 32 potential national park areas according to the 4 measures of recreational values.

Area-Selection Methods

We selected areas based on complementary species richness (Pressey and others 1993) to identify the potential national park areas most important for biodiversity. We generated near-maximal covering sets (Church and others 1996) to select national parks, which represent the maximum possible representation of the species. We selected areas using the progressive rarity algorithm (Margules and others 1988, Williams 1998) of WORLDMAP software (Williams 2000). This algorithm initially selects all areas with species that have single records. In successive iterations of the algorithm, areas with the highest complementary richness in the rarest species are selected until the required number of areas has been obtained (see Table 1 in Williams and others 2000). Differences in area could potentially cause differences in results because land area of the potential national parks is variable. To control for the effect of area, we also generated maximal covering sets that maximize species representation within a given total land area rather than a given number of areas.

Each of the 4 recreational measures contained some uncertainties and potential biases; therefore, we did not use the 4 measures of recreational value directly as a cost function in the aforementioned selection of candidate national parks (i.e., optimizing species representation per value rather than per number of area). Instead, we applied a more indirect approach by ranking the 32 areas according to each of the 4 measures of recreational value and chose the 7 highest-ranked areas for each measure. We then ended up with a total of 16 areas constituting the most important areas for recreational values according to our measures. Among these 16 areas, we selected a maximal covering set of 7 areas to optimize species representation. Therefore, we selected 7 areas to optimize species representation among the 16 areas with highest recreational value.

We evaluated the effectiveness of the 7 pilot areas, defined as the total number (or percentage) of species represented, by comparing them with 2 benchmarks: (1) the effectiveness of near-maximal covering sets of 7 areas chosen among all 32 areas and (2) the effectiveness of 7 areas selected randomly (1,000 times with upper and lower 2.5% tail).

Analysis was carried out separately for all species, all threatened species, and all EU species. To some extent, 2 of the 7 pilot areas were chosen mainly to represent marine values, although they hold relatively many terrestrial species (they hold 44% and 51% of the 973 species, respectively). Nevertheless, because our data set included terrestrial and freshwater species only, we also performed maximal covering analyses for the selection of 5 areas for comparison with the 5 pilot areas from which the 2 mainly marine areas had already been excluded.

Results

Efficiency of the 32 Larger Danish Nature Areas

Altogether, the 32 potential national parks, i.e. the larger nature areas in Denmark, do not include all of the species from the original data set (compiled for 10 km UTM quadrates covering the entire country). The 32 areas comprise 973 of all 1,008 species (97%), 157 of 180 threatened species (87%), and 70 of 72 EU species (97%).

Figure 2 shows how species representation increases with the number of national parks selected. After the initial selection of a few parks, additional parks only contributed to slight increases in the overall representation of all species (i.e., representation of the 973 species). However, if we solely consider threatened or EU species, additional numbers of parks will have a higher impact on the effectiveness of species representation. For example, increasing the number of parks from 3 to 7 increases overall species richness from 85% to 93%, whereas species representation increases from 63% to 83% for threatened species and from 69% to 87% for EU species, respectively. Furthermore, even a few national parks are

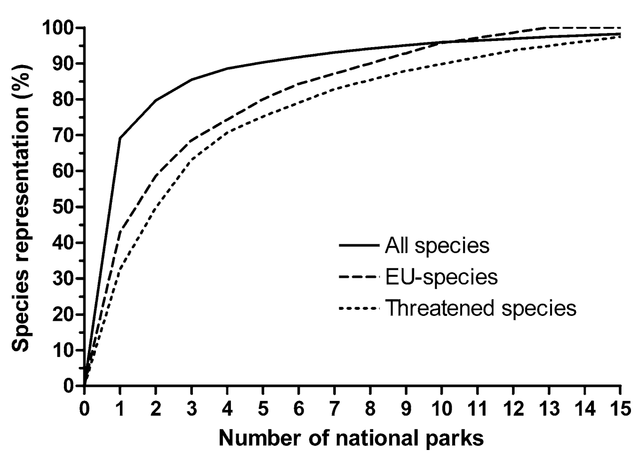

Fig. 2 Cumulative percent representation of all species, threatened species, and EU species by the maximal covering set of 15 potential national park areas identified based on data on all species, threatened species, and EU species

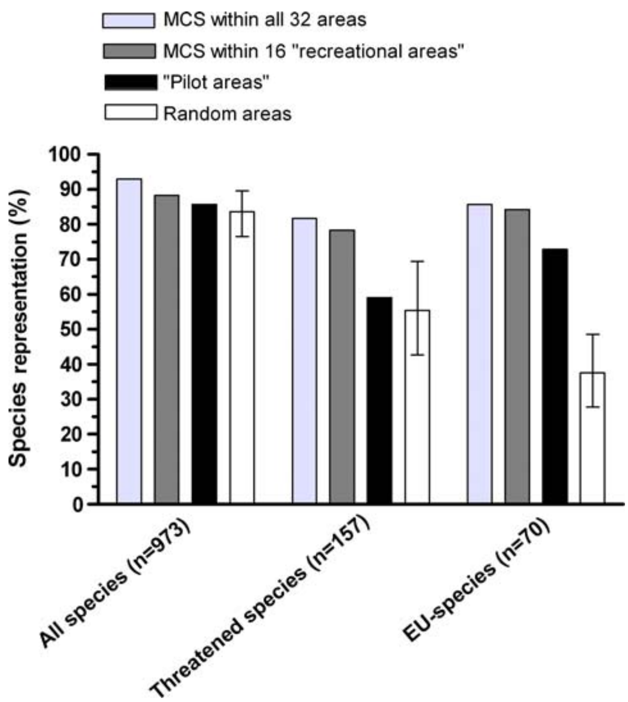

Fig. 3 Percent representation of all species, threatened species, and EU species by 7 randomly selected areas, 7 pilot areas, the maximal covering set of 7 areas among all 32 areas (identified based on species, threatened species, and EU species), and the maximal covering set of 7 areas among the 16 areas most important for recreational values (identified based on species, threatened species, and EU species). MCS = maximal covering set. Error bars denote 95% confidence intervals

quite effective in representing species; four national parks can represent up to 89% of all species, 71% of threatened species, and 74% of EU species.

Efficiency of the Seven Pilot Areas

The 7 pilot areas represent 86% of all species and 59% of threatened species, which is not significantly better than the effectiveness achieved by the random selection of 7 areas (Fig. 3). It is only when the representation of EU species (73%) is considered that the 7 pilot areas perform significantly better than random area selection. In comparison, the maximal covering set of 7 areas based on all species represents 93% of the species. When considering threatened and EU species, the maximal covering sets represent 82% and 86%, respectively. In all 3 cases, the maximal covering sets are more effective than the 7 pilot areas, with most pronounced differences for the species of most conservation concern, i.e., threatened and EU species.

The total land area of the 3 maximal covering sets is considerably larger than the total land area of the 7 pilot areas, which potentially could be the main explanation of the higher effectiveness achieved by the maximal covering sets. However, this is not the case because 1 or 2 large areas can be substituted in any of the 3 maximal covering sets, resulting in sets with total land areas slightly smaller than the 7 pilot areas but still with considerably more species represented. Furthermore, the maximal covering sets that control for area effect (i.e., maximize representation of species per land area rather than number of areas), each constitutes 9 areas (equivalent in size to the 7 pilot areas, i.e., approximately 1.565 km^2) and represent 93% of all species, 82% of threatened species, and 89% of EU species. This is similar to, or, in the case of EU species, even better than the effectiveness of the maximal covering sets of 7 areas presented previously. Consequently, the differences in effectiveness between maximal covering sets and the 7 pilot areas are not caused by differences in actual sizes of land area.

Two of the 7 pilot areas were chosen to some extent because of marine values, which might explain the relatively poor performance of species representation by the 7 pilot areas because our analysis mainly focused on terrestrial species. However, the same pattern is found if we consider only the 5 pilot areas selected mainly for terrestrial values. These areas represent 83% of all species, 49% of threatened species, and 66% of EU species. This is less effective than the maximal covering sets of 5 areas that represent 90% of all species, 76% of threatened species, and 78% of the EU species. Therefore, the relative differences in effectiveness between the maximal covering sets

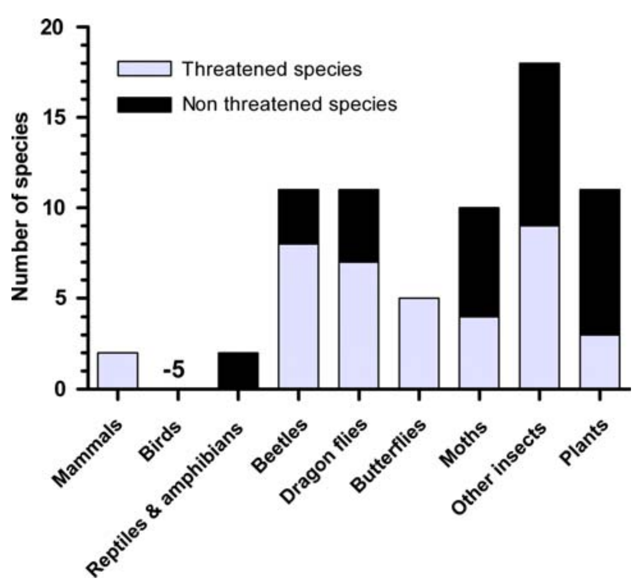

Fig. 4 The additional number of species (all species and threatened species) from the various taxonomic groups covered by the maximal covering set of 7 areas (based on threatened species) compared with the 7 pilot areas

and the pilot areas were close to the differences found when analysis was performed on 7 areas.

A final concern could be that the differences in effectiveness between the maximal covering sets and the 7 pilot areas were merely caused by a single taxonomic group (e.g., hoverflies) and therefore were less robust. Therefore, for the maximal covering set based on threatened species, we examined to what extent individual taxonomic groups contributed to the increased effectiveness of the maximal covering set compared with the 7 pilot areas. Figure 4 shows the additional number of species represented in the maximal covering set for threatened species. We see that for all taxonomic groups, except for birds, the maximal covering set represents more species than the pilot areas (Fig. 4). In general, the maximal covering sets showed a high degree of flexibility in area choices, i.e., several different sets of 7 areas could represent species with almost the same overall effectiveness.

Biodiversity and Recreational Values

The maximal covering sets of 7 potential national parks selected among the 16 most important areas for recreational values performed well in representing species (Fig. 3). Because these maximal covering sets represent 91% of all species, 78% of threatened species, and 84% of EU species, they are considerably more effective than the 7 pilot areas and nearly as effective as the maximal covering set selected among all 32 potential national parks. Four of the 7 pilot areas are ranked among the 16 most important areas for recreational values (Appendix 1).

Discussion

National Parks and Biodiversity Conservation

Even if all of the larger nature areas in Denmark were established as national parks, all of the species in our data set would not be represented, in particular, threatened species would not be fully included (13% would be missing). These results may be explained by the high degree of fragmentation and intensification of the Danish landscape, which may restrict some species from occurring in the larger remaining natural and seminatural areas. Alternatively, some rare species may only have suitable habitat left in the areas, which, because of human influence, are no longer part of any larger coherent natural or seminatural area. In any case, continuing the existing management of the smaller biotopes not associated with the larger natural areas seems essential to conserve biodiversity in Denmark. Nonetheless, our results show that conservation of the larger areas as national parks can provide a significant contribution to the conservation of species richness in Denmark. The establishment of a few national parks can represent a high proportion of the species, including the species of most conservation concern.

The establishment of any of the 32 areas as national parks would inevitably benefit biodiversity because management and further protection of larger coherent natural areas will probably provide better long-term survival for many species. For example, some species will be able to maintain higher populations, which will in return provide higher resistance to disturbances. Furthermore, the edge effect, e.g., from a highly intensive agriculture, will decrease and thereby benefit ecosystems, species, and habitats.

Efficient National Park Design for Biodiversity

Although establishment of national parks per se would be beneficial to biodiversity, not all of the potential national parks are equally effective as components of a network of parks aiming to represent species richness. Surprisingly, we found that the 7 a priori–selected pilot areas were not significantly more effective in representing all species and threatened species than 7 areas selected by chance. It is only if we consider the representation of EU species that the 7 pilot areas performed more effectively than random selection of areas, which can be explained by the relatively good representation of birds by the 7 pilot areas (birds make up a high proportion [40%] of EU species). If 7 parks were selected to optimize species representation, the effectiveness in representing species can be considerably improved compared with the 7 pilot areas, in particular for threatened and EU species. Furthermore, our analysis suggests that this overall finding cannot be attributed to other possible explanations, such as land area. For example, the land area of the 32 potential national parks is variable, and the total land area of the 3 maximal covering sets is considerably larger than the total land area of the 7 pilot areas. However, our analysis controlling for area showed that this factor is not responsible for the difference in species richness. Likewise, restricting the analysis to the 5 mainly terrestrial pilot areas showed similar results. Finally, we found that the higher effectiveness of the maximal covering set was driven by most taxonomic groups. Furthermore, as biodiversity surrogate, we used species and did not consider habitat types. Therefore, the pilot areas may be better in representing different characteristic habitat types. However, because most of the habitat types exist in several areas, it is doubtful whether the 7 pilot areas performed better in this respect compared with alternative area networks. This assumption was confirmed by a preliminary analysis based on the distribution of several habitat types defined in Danish legislation and in the Habitats Directive (Petersen and others 2005).

Recreational Values and Biodiversity

Our findings suggest that when selecting networks of national parks, it is possible to achieve a synergy between outdoor recreation and biodiversity conservation. Among the 16 highest ranked potential national parks in terms of recreational values, we selected 7 areas that represent species almost as effectively as the 7 areas chosen among all of the 32 potential national parks. This overall finding was supported by a recent case study from California, in which Chan and others (2006) found that networks selected for biodiversity conservation performed well in meeting their recreation targets. Their measure of recreational value was mainly a function of the amount of natural and seminatural habitats and area accessibility in terms of their proximity to population centers and major roads (Chan and others 2006). However, the issue of synergy between biodiversity conservation and recreational value has so far been little explored, and further research is needed to draw any firm conclusions. Nevertheless, it is encouraging that these first attempts suggest possible synergies between biodiversity representation and recreational value when selecting sites for conservation. If conservationists can show that multiple public goods and services, such as biodiversity conservation and recreation, can be provided efficiently from a small set of locations, it may help engage a broader range of public support for conservation because an increase in visitor numbers can improve biodiversity awareness and conservation. However, this possible synergy also holds a potential conflict with biodiversity conservation because an increase in visitor numbers may degrade habitat quality for some species because of increased direct disturbance and disturbance associated with building infrastructures to provide better access (Young and others 2005).

In the case of the 7 pilot areas, they should also provide attractive nature experiences for visitors according to the stated objectives of national parks in Denmark. However, according to our analysis, recreational values for the 7 pilot areas were not particularly good compared with other parks. Therefore, a potential favoring of recreational value compared with biodiversity in the selection process does not seem to explain why the 7 pilot areas perform relatively poorly in representing species.

Multifunctionality of National Parks

National parks may have goals other than species conservation and recreational values. In the case of national parks in Denmark, the official goals also include representation of cultural heritage and spectacular landscape features, etc. Unfortunately, data of sufficient quality to assess cultural heritage or landscape features of potential national parks were not available. Therefore, we cannot rule out that the a priori set of potential national parks perform better than alternative sets in terms of expressing these values, and this could explain why the pilot areas performed less well in representing species. We also cannot explore possible trade-offs and synergies between these other goals of national parks compared with biodiversity conservation.

Finally, the designation of national parks is inevitably constrained by real-world factors, such as economy (e.g., cost of national parks) or potential conflicts (e.g., complicated landowner relations). Had data of sufficient quality been available, it would have been illuminating to have incorporated cost measures for the potential national parks (e.g., costs of establishment) and cost–benefit analyses into the analyses as an actual cost instead of actual size of land area or number of areas (Moore and others 2004) or into more established multicriteria decision-making methods (see Moffet and Sarkar 2006 for overview). Moreover, these factors can also be used to determine the most appropriate protected-area category.

Caveats

Some caveats apply to this study. First, when assessing biodiversity value, we solely assessed species representation. Therefore, because there was a lack of data, we did not consider persistence in terms of viable populations, nor did we consider other ecosystem services than outdoor recreation. Second, it should be noted that data on plants made up only a minor proportion of the extensive data set used for the analyses. The results seem robust with regard to animals, although we cannot rule out that the 7 a priori pilot areas would perform better for groups of species not considered in this analysis. We also cannot rule out the possibility that the general pattern may be somewhat different for plants. However, we have no reason to believe that the overall findings per se should change because of inclusion of more plant data. In fact, the trends in changes were consistent for almost all taxonomic groups (Fig. 4), including the plants for which we had data. Furthermore, our data set included many groups of insects, e.g., butterflies, which in distribution may be expected to covary to some extent with plants due to the coevolutionary development of these groups. Third, the recreational measures contained some biases, and our analysis was restricted to these four aspects of recreational value. For example, we did not directly "maximize" the recreation benefits of a set of parks by providing opportunities close to all population centers, and thus the geographic spread of parks for recreation in relation to cities was not directly considered.

Concluding Remarks

We found that national parks, as larger areas, can make a considerable contribution to species representation in Denmark, although protection of smaller biotopes is still necessary. Although, it has been well known from many, mostly theoretic, studies that systematic conservation planning is more efficient than ad hoc conservation planning, only few studies provide results from real-world cases. Our quantitative analysis on this Danish case suggest that the 7 a priori pilot national park areas are suboptimal in conserving species and thus illustrate how rigorous data-driven analysis could have provided valuable information to support the decision-making process. Nonetheless, the data-driven analysis should not be viewed as an exclusive method ignoring the human dimension of decision making but rather as a complement to elucidate potential consequences and cost for various decisions possible to reach a society-defined goal. An important aspect of data-driven analysis is the possibility to identify synergies between different goals and thus identify solutions that fulfill several goals simultaneously. In this case, we found a promising synergy between biodiversity and recreational value, which holds the potential to engage a broader range of public support for conservation. Further research is urgently needed to explore the synergies between ecosystems services and biodiversity to provide efficient planning to address the 2010 target.

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Appendix 1 Recreational value of potential national park areas[a]

Rank	No. of visitor hours per year (× 1000)		Rank	Estimated visitor potential (no. of car visits per year per km^2)		Rank	Travel distance (km)		Rank	No. of foreign car visit hours (hours per year)	
1	Københavns Omegn (19)	21,880	1	Københavns Omegn (19)	1,050	1	Ulkjær Mose/ Hjøllund/Vrads (14)	98	1	**Vadehavet (24)**	707,187
2	**Vadehavet (24)**	5,260	2	Dybbøl/ Sønderborg (32)	950	2	**Thy (7)**	97	2	Ringkøbing Fjord (17)	116,137
3	**Nordsjælland (15)**	4,889	3	Roskilde/Lejre (20)	900	3	Ringkøbing Fjord (17)	88	3	**Møn (30)**	107,497
4	**Møn (30)**	1,883	4	**Nordsjælland (15)**	850	4	Det Sydfynske Øhav (31)	84	4	Skagen (1)	77,648
5	Skagen (1)	1,422	5	**Møn (30)**	750	5	**Møn (30)**	80	5	Københavns Omegn (19)	75,810
6	Ringkøbing Fjord (17)	1,124	6	Svaninge Bakker (28)	700	6	Hanherred/Vejlerne (6)	76	6	Hanherred/Vejlerne (6)	64,358
7	Bornholm (26)	1,104	6	Jægerspris Nordskov (18)	700	7	**Lille Vildmose (8)**	64	7	Bornholm (26)	63,809
8	Hanherred/ Vejlerne (6)	966	8	Vojens-Haderslev Ådal (27)	600	8	Skagen (1)	59	8	**Thy (7)**	44,951
9	Det Midtjyske Søhøjland (13)	883	8	Det Sydfynske Øhav (31)	600	9	Midjyske Heder/ Karup Å (10)	58	9	Vestjylland (11)	42,137
10	**Thy (7)**	847	10	**Mols (12)**	550	10	**Vadehavet (24)**	57	10	Kallenmærsk Hede/ Varde Å (23)	31,708
11	Vojens-Haderslev Ådal (27)	804	10	Tystrup-Bavelse/ Suså (25)	550	11	Kallenmærsk Hede/ Varde Å (23)	52	11	Det Sydfynske Øhav (31)	30,752

Appendix 1 continued

Rank	No. of visitor hours per year (× 1000)		Rank	Estimated visitor potential (no. of car visits per year per km^2)		Rank	Travel distance (km)		Rank	No. of foreign car visit hours (hours per year)	
12	Vestjylland (11)	737	10	Bornholm (26)	550	12	Vejle Å/Grejsdalen (22)	51	12	**Mols (12)**	28,460
13	Dybbøl/Sønderborg (32)	668	10	Vejle Å/Grejsdalen (22)	550	13	Dybbøl/Sønderborg (32)	50	13	**Læsø (3)**	23,993
14	Roskilde/Lejre (20)	629	14	Rold Skov (9)	500	14	Vestjylland (11)	50	14	**Nordsjælland (15)**	20,386
15	**Mols (12)**	616	15	Skagen (1)	450	15	Det Midtjyske Søhøjland (13)	49	15	Dybbøl/Sønderborg (32)	14,191
16	Rold Skov (9)	544	15	Tolne/Tolshave (2)	450	16	Vojens-Haderslev Ådal (27)	45	16	Det Midtjyske Søhøjland (13)	8,995
17	Midjyske Heder/ Karup Å (10)	535	17	**Thy (7)**	400	17	**Mols (12)**	42	17	Vojens-Haderslev Ådal (27)	8,586
18	Det Sydfynske Øhav (31)	511	17	**Vadehavet (24)**	400	18	Rold Skov (9)	42	18	Rold Skov (9)	3,624
19	Kallenmærsk Hede/ Varde Å (23)	362	17	Det Midtjyske Søhøjland (13)	400	19	**Nordsjælland (15)**	38	19	Svaninge Bakker (28)	2,258
20	Svaninge Bakker (28)	278	17	Hanherred/Vejlerne (6)	400	20	Roskilde/Lejre (20)	36	20	Ulkjær Mose/ Hjøllund/Vrads (14)	1,698
21	Tystrup-Bavelse/Suså (25)	273	17	Ringkøbing Fjord (17)	400	21	Københavns Omegn (19)	33	21	Jægerspris Nordskov (18)	1,198
22	**Læsø (3)**	272	22	Store Vildmose (5)	350	22	Jyske Ås (4)	32	22	Midjyske Heder/ Karup Å (10)	1,142
23	Jægerspris Nordskov (18)	252	22	Kallenmærsk Hede/ Varde Å (23)	350	23	Tystrup-Bavelse/ Suså (25)	30	23	Roskilde/Lejre (20)	872
24	Vejle Å/Grejsdalen (22)	162	22	Vestjylland (11)	325	24	Svaninge Bakker (28)	29	24	Tystrup-Bavelse/Suså (25)	641
25	Ulkjær Mose/ Hjøllund/Vrads (14)	86	22	Midjyske Heder/ Karup Å (10)	325	25	Bornholm (26)	28	25	Vejle Å/Grejsdalen (22)	194
26	Jyske Ås (4)	32	26	Åmosen/Tissø (21)	300	26	Jægerspris Nordskov (18)	24	26	**Lille Vildmose (8)**	0
27	**Lille Vildmose (8)**	18	26	Smålandsfarvandet (29)	300	27	Tolne/Tolshave (2)	20	26	Tolne/Tolshave (2)	0
28	Tolne/Tolshave (2)	8	28	**Læsø (3)**	275	28	**Læsø (3)**	11	26	Jyske Ås (4)	0
–	Skjern Å (16)	–	29	**Lille Vildmose (8)**	250	–	Skjern Å (16)	–	–	Skjern Å (16)	–
–	Åmosen/Tissø (21)	–	29	Jyske Ås (4)	250	–	Åmosen/Tissø (21)	–	–	Åmosen/Tissø (21)	–
–	Smålandsfarvandet (29)	–	29	Ulkjær Mose/ Hjøllund/Vrads (14)	250	–	Smålandsfarvandet (29)	–	–	Smålandsfarvandet (29)	–
–	Store Vildmose (5)	–	32	Skjern Å (16)	150	–	Store Vildmose (5)	–	–	Store Vildmose (5)	–

[a] Ranking of the 32 potential national park areas according to the 4 measures of recreational value. The pilot areas are highlighted in bold. The numbers in brackets refer to the numbers in Fig. 1a

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