# Are the current conservation efforts supporting an efficient management port-folio in a world of change?

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## 1 Introduction

At a European level, agriculture is becoming both more intensive in terms of nitrification and land use. While less productive areas in the European Union in particular are set aside or made more extensive, fertile agricultural areas are being intensively exploited. Simultaneously, world-wide, in a European context and in Denmark, society attaches increasing importance to protection of overall diversity of the landscape in terms of its scenery, species and cultural history. On top of that, the climate change and its possible implications for eco-systems as well as human systems have initiated the need to discuss whether the current designation of conservation areas holds an efficient port-folio in terms of species protected and management options.

Interestingly, in 2000, the Danish Economic Council, in collaboration with biologists of the University of Copenhagen, evaluated the efficiency of the current management of Danish biodiversity (DORS 2000, Lund and Rahbek 2000). They found that the management was insufficient in coverage of all species and relatively cost-ineffective; a strategy with a quantitative, data-driven approach based on, e.g. iterative site-selection algorithms (Vane-Wright et al. 1991, Pressey et al. 1996, Williams 1998, Reyers et al. 2000, see also Hopkinson et al. 2000) could in principle ensure a much more cost-effective strategy and provide a basis for priorities of in situ management of biodiversity in Denmark.

Similar to the situation of other countries, protecting existing nature areas in Denmark may not be sufficient to sustain the long-term preservation of the Danish flora and fauna (Wilhjelm Committee 2001a). New areas with habitat suitable for wildlife need to be established through means of, e.g. allowing natural succession and/or direct restoration of former nature areas. Such strategies are currently being both discussed and implemented in Denmark (Wilhjelm Committee 2001b), latest with the designation of five National Parks. Thus, for the first time in decades, opportunities to select and prioritise new areas for biodiversity management are a reality. Many existing natural areas managed for conservation are selected not only for their biological value but also because of their scenic beauty or because they had no obvious alternative economic value (Pressey 1994). Hence, more than single dimensional decision making is needed to make appropriate decisions. In terms of biodiversity, however, previous studies have demonstrated that the current choice of National Parks may not be wiser in terms of efficiency and effectiveness than simple random selection of such parks, if the main goal is to concentrate efforts on species protection (Larsen et al. 2008, in press). This underlines the need for conservation research in Denmark as well as at a European level, which may guide the future selection of conservation areas and ensure coordination between different Member States as well as between different geopolitical regions within the Member States. And even more important, uncertainty about climate change effects on biodiversity and consequences for conservation efforts needs to be addressed not only locally, but also regionally and globally.

## 2 Prioritising conservation investments in a changing world

A large number of economic valuation studies on biodiversity are found in the literature (see Nunes et al. 2003 for a review), and a number of them are relevant to forest biodiversity conservation. So far, however, only a few results from this literature have been successfully applied to designing conservation strategies (e.g. Naidoo and Iwamura 2007). An important future research question is the potential of environmental valuation research in guiding forest and nature conservation strategies. Since only limited resources are available for investment in nature protection allocating the resources efficiently would be helped by an increased understanding of not only the economic costs of conservation strategies, but also of the associated benefits. Such cost-benefit analysis is indeed common in many project appraisals, but rather limited within conservation biology. Decision-makers are often left with quite reliable estimates of conservation costs (effort) but less reliable estimates on the value of such effort. In many cases, the marginal cost of supplying more protected biodiversity will be very different from the marginal benefits of such provision. Figure 1 illustrates a simple example of potential implications for identifying priority for approximately 40 conservation areas. Each area has a potential conservation value and cost. The most cost-effective areas (highest B/C ratio) are located in quadrant 1 and the ones which should be prioritised first. Areas in quadrants 2a and 2b are inferior to areas in quadrant 1. Most likely 2a, if budgets are available, is preferable to 2b because of its higher benefits. Finally, the least prioritised areas with the lowest conservation benefits and still high conservation costs are in quadrant 3.

Figure 1 also illustrates how climate change may require larger investments in ensuring suitable habitat. Some species may move from left to right (e.g. from quadrant 1 to 2a or even further out of 2a) and others may move from right to left because of improved habitat quality. It is even more interesting that the priorities may change if the preference for a species decreases. So far most research has focused on stochastic costs and species distributions. Much less research has been invested in understanding the dynamics of biodiversity preferences. One example is the high political interest in protecting national breeding species, and much less interest in reserving areas for species, which may become national breeding species in the future due to, e.g. climate change. Other attributes (e.g., changing status as an icon species, changing protection status at an EU level) may of course change the preferences or benefits of protecting particular species or areas.

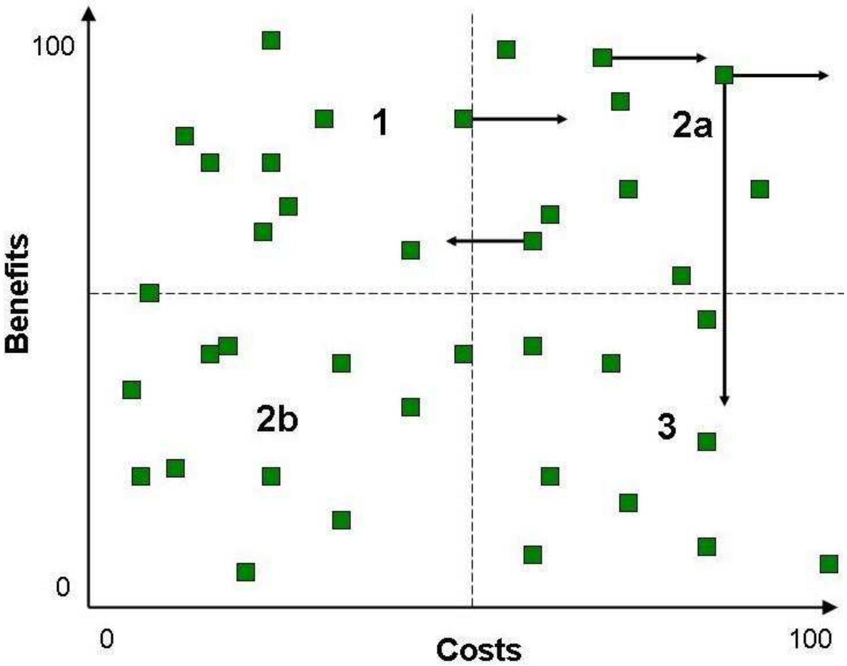


**Figure 1**. Changes in priorities when costs and benefits are dynamic (modified from Margules and Pressey 2000).

Species 'moving out' may then at some point move not only to the right but also downwards from quadrant 2a to quadrant 3. This leaves us with an interesting question: when to stop investing in one species and shift to exercise the investment in other species? Much resemblance to the questions analysed in the real options literature, which treat management planning decisions with long-ranging and irreversible consequences. These properties are well known in other economic disciplines where economists have for more than three decades worked on how uncertainty about possible future states in a dynamic world can be explicitly modelled and analysed. In particular, studies on uncertainty and irreversibility have attracted much attention (e.g. Arrow and Fisher 1974, Henry 1974, Insley 2002, Alvarez and Koskela 2006). Where Arrow and Fisher (1974) and Henry (1974) considered the problem of developing wilderness, when the future benefits from conservation and development are uncertain, more recent studies analyse the value of flexibility in management options (McDonald and Siegel 1985, McDonald and Siegel 1986, Brennan and Schwartz 1985). Another interesting aspect of the future provision of environmental services is that many of them may be jointly produced. A number of environmental services rely on the conservation of land. If the land is intensively managed for agricultural production, this may have an irreversible or at least long-term negative impact on the values of these ecosystem services. Assume a piece of conservation land where future values of ecosystem services are uncertain, where the decision problem is either to exercise the conversion of land to intensive agricultural production or continue maintaining the flow of environmental services from the land. Assume the landowner gains utility of ecosystem services as well as from agricultural production. He then maximises the expected present value $V(A,B,W)$, of converting to agriculture ($A$) or continuing the provision of services such as biodiversity ($B$) and clean drinking water ($W$):

$$V(A,D,W) = \max\{A - C; E[V(A + \Delta A, B + \Delta B, W + \Delta W)]\}.$$

Where this approach considers a decision which is irreversible another approach could be undertaken which allows for more flexible management options. As mentioned above the utility of selected areas may change when habitat quality and species composition change. Therefore it may be more advantageous to ‘regret’ previous decisions on designated conservation areas, and sell or stop subsidising areas which turn out to contain low conservation values in the future. Hence the maximisation problem rather looks like maximising the expected utility of species survival in unprotected sites ($N$) as well as protected sites ($R$) by protecting areas $X$ allowing for swapping previous protected areas $L$:

$$U(S(N_t, R_t)) = \max_{\substack{X_t \le N \\ L_{t_t} \le R}} E(U(S(N_{t+1}, R_{t+1}))) \; .$$

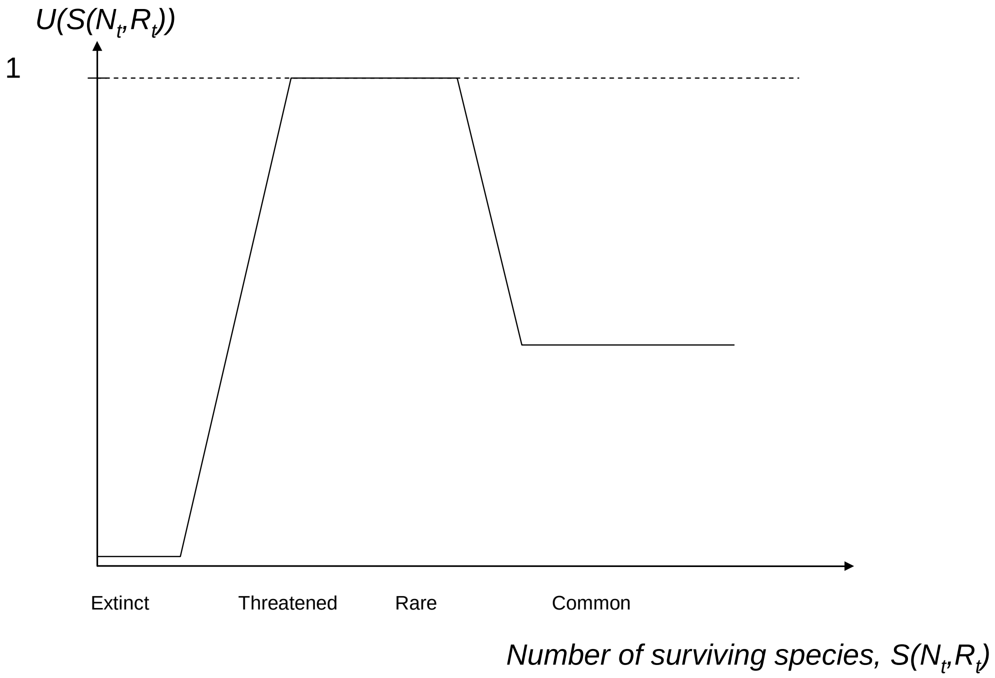


**Figure 2**. Utility of conservation efforts to protect extinct species may be lower than common species, which may hold lower utility than species which are threatened or rare.

## 3. Concluding remarks

Human activities are rapidly increasing the number of species threatened with extinction, increasing the conservation needs globally. Yet, resources available for protection are strongly limited. This increases the interest in identifying which areas of habitat are the most important to protect in order to preserve biodiversity for the future. However, as discussed in this presentation, the condition of land areas may change in the future, thereby influencing the biodiversity they contain. Conservation authorities are thus facing the problem of how to target their actions so that they accomplish the most with limited budgets, while acknowledging the uncertainty of the future states of areas and of the environment globally. This issue is at the very forefront of conservation planning. This presentation discusses the need for evidence based conservation decisions in dynamic world, and stress the potential insights gained using sound and theoretically based dynamic decision-making models. The presentation finalises by discussing the establishment of a portfolio of management alternatives such as national parks, corridors/stepping stones, set a site agricultural areas, to enhance adaption to climate change.

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