Silva Fennica - PRIFOR2010

Protecting forest areas for biodiversity in Sweden 1991-2010: the policy implementation process and outcomes on the ground

2011-10-30

Per Angelstam (1), Kjell Andersson (1), Robert Axelsson (1), Marine Elbakidze (1), Bengt-Gunnar Jonsson (2), Jean-Michel Roberge (3)

(1) School for Forest Management, Faculty of Forest Sciences, Swedish University of Agricultural Sciences (SLU), SE-73921 Skinnskatteberg, Sweden

(2) Department of Natural Science, Engineering and Mathematics, Mid Sweden University, SE-851 70 Sundsvall, Sweden

(3) Department of Wildlife, Fish and Environmental Studies, Faculty of Forest Sciences, Swedish University of Agricultural Sciences (SLU), SE-90183 Umeå, Sweden

per.angelstam@slu.se; kjell.andersson@slu.se; robert.axelsson@slu.se; marine.elbakidze@slu.se; jean-michel.roberge@slu.se; bengt-gunnar.jonsson@miun.se

Abstract

Current Swedish forest and environmental policies imply that forests should be managed so that all naturally occurring species are maintained in viable populations. This requires maintenance of functional networks of representative natural forest and cultural woodland habitats. We first review the policy implementation process regarding protected areas for biodiversity conservation in Sweden 1991-2010, how ecological knowledge was used to formulate interim short-term and strategic long-term biodiversity conservation goals, and the development of a hierarchical spatial planning approach. Second, we present data about the amount of formally protected and voluntarily set aside forest stands, and evaluate how much remains in terms of additional forest protection, conservation management and habitat restoration to achieve forest and environmental policy objectives in the long-term. Third, to demonstrate the need for assessment of the functionality of forest habitat networks a case study in central Sweden was made to estimate the functionality of old Scots pine, Norway spruce and deciduous forest habitats, as well as cultural woodland, in different forest regions. Finally, we assess the extent to which operational biodiversity conservation planning processes take place among forest owner categories and responsible government agencies. We conclude that Swedish policy pronouncements capture the contemporary knowledge about biodiversity and conservation planning well. However, the existing area of protected and set-aside forests is presently too small and with too poor connectivity to satisfy current forest and environmental policy ambitions. To bridge this gap, spatial planning, management and restoration of habitat, as well as collaboration among forest and conservation planners to create and maintain functional habitat networks need to be improved.

Keywords: forest protection, restoration ecology, forest policy, connectivity, green infrastructure, umbrella species, forest disturbance regimes, participation and collaboration

1 Introduction

Concerns about species' extinction emerged in Sweden more than a century before (Säve 1877) the term biodiversity appeared (Wilson 1988). Already in 1909 the Swedish Parliament passed an act for the establishment of national parks in order to protect the natural environment for the benefit of science and tourism. However, modern forest conservation including area protection to secure habitat for species emerged only in the mid to late 20th century. This can be traced to public reactions against intensive forest management, which commenced after the 1948 forest policy that focused on sustained yield forestry. That policy resulted in forest plantation on cultural woodlands, loss of old-growth forest (Rosén 1953), creation of large clear-cuts (Jordbruksdepartementet 1974), and use of herbicides to remove the deciduous component in young forests in the 1970s (Enander 2003).

The State Forests (*Domänverket*) began setting aside forest areas for conservation, so called *Domänreservat*, already in 1913, and stipulated nature considerations in managed forests in 1924 (Domänverket 1951, Oldertz 1959). The Nature Conservation Act of 1964 permitted the establishment of nature reserves, and the Swedish Environmental Protection Agency was created in 1967, one of its missions being nature conservation. At the end of the 1980s, an increase in protected areas was linked to the information gained from a nation-wide old-growth forest inventory conducted between 1978 and 1981 (Naturvårdsverket 1982). This inventory was the first systematic effort carried out to improve forest protection for nature conservation purposes. In 1988, county administrative boards, especially in northern Sweden, protected a number of large sub-alpine forests as nature reserves. In the early 1990s there was a substantial area increase in the amount of formally protected areas, mostly due to the conversion of protected state forest company reserves to nature reserves in Norrbotten County in northernmost Sweden (Höjer 2009).

Simultaneously, a gradual development of nature conservation policy regarding the managed forest landscape took place. In 1979 a section (§21) was added to the 1948 forestry act with the aim to implement stand-scale nature considerations in operational forest management in general. Following its tradition of using advice to forest owners and education as its main policy implementation tools, the National Board of Forestry arranged several broad educational programmes where nature conservation was an important part, and green forest management plans with specific focus on maintaining habitat for species appeared (Angelstam 2003, Naturvårdsverket and Skogsstyrelsen 2005).

From the late 1980s forest conservation was mainly influenced by various national and international environmental organizations (e.g., Kortelainen 2010), the emergence of the concepts of sustainable development and sustainability principles (Axelsson et al. in press), and different international agreements and conventions about forests (Angelstam et al. 2004a). This development also led to the introduction of the woodland key habitat (WKH) concept (Nitare and Norén 1992, Timonen et al. 2010) for voluntarily set-aside of forests and a corresponding nation-wide mapping of WKHs, the introduction of environmentally driven forest certification (FSC and PEFC; e.g., Auld et al. 2008), and substantially increased resources for protection of forest areas with high natural values for conservation purposes. In the early 1990s the first ideas about landscape planning and the use of a landscape perspective for forest conservation emerged, encouraging collaboration among forest owners (Angelstam 2003), and the first Swedish nature conservation strategy appeared (Naturvårdsverket 1991).

Hence, the conservation of biodiversity – i.e. the composition, structure and function of ecosystems (Noss 1990) – became one of the nationally agreed objectives of forest management in Sweden (Regeringens proposition 1992/93:226, Regeringens proposition 2007/08:108). Since 1993 conservation and production are formally recognized as equal objectives of forest management in Sweden (Bush 2010). In addition to this national policy development, Sweden has adopted several Pan-European (MCPFE 1993, European Landscape Convention 2000) and EU policies and directives such as the EU Birds, Habitat and Water Framework Directives (European Commission 1979, 1992, 2000), all of which include different legal obligations for biodiversity conservation in forests.

Biodiversity conservation involves the establishment, management and restoration of functional habitat networks including protected areas. The term 'green infrastructure' captures this (Regeringens proposition 2008/09: 214). Realising this is an example of a societal process about implementing policies on ecological sustainability. Consequently the topic is inherently interdisciplinary (e.g., Angelstam et al. 2003a, Vucetich and Nelson 2010). While biodiversity conservation has been clearly pronounced in international and national policies, the subsequent implementation process needs to be assessed as to its effectiveness (Lee 1993, Angelstam et al. 2003a). Indeed, evaluating policy and governance processes and management outcomes for biodiversity conservation is a crucial step in the progress toward agreed policy goals. In the case of biodiversity conservation this requires both an evaluation of the policy process, and of the outcomes of this process (Rauschmayer et al. 2009). Evaluation of the policy process involves assessment of what is good or democratic governance (Currie-Alder 2005, Baker 2006, United Nations 2010), including elements such as more and improved information management and learning, a legitimate process, and the normative aims of transparency and participation. The outcomes of policy processes have two parts (Rauschmayer et al. 2009). Firstly, the outputs in terms of implementation of policy norms and rules to be applied by governors, and pronouncements in terms of strategic performance targets for short-term and long-term goals for the amount of protected areas (e.g., Angelstam and Andersson 2001), retention of fine-scale nature consideration elements in forestry operations

(Vanha-Majamaa and Jalonen 2001), as well as tactical spatial planning and management approaches (Eriksson and Hammer 2006). Secondly, the consequences of actual operational implementation of plans on the ground by managers in terms of a sufficiently extensive network of representative habitats, and spatial planning to enhance functionality for species and processes.

In 1999, a series of national environmental objectives were adopted by the Swedish parliament, including the "Sustainable Forests" objective. One of the interim targets under that objective was to increase the amount of formally protected forest by 400,000 ha and the area voluntarily set aside forests by 500,000 ha in productive forests below the mountain region before the end of 2010 (Regeringens Proposition 1997/98:145, 2000/01:130). In 2006, the Swedish Forest Agency began an in-depth evaluation of the Sustainable Forests objective (Skogsstyrelsen 2007, Statskontoret 2007, Miljömålsrådet 2008). The aims of this assessment were three-fold. First, to review empirical knowledge about conservation biology as a basis for updating the strategic short-term (the interim target) and long-term goals for biodiversity conservation by forest protection, which were formulated in 1997 (SOU (Statens Offentliga Utredningar) 1997a,b). The results did not evoke changed goals. Second, to describe the development of the amount of protected areas in Sweden's managed productive and non-productive mountain forests. This evaluation concluded that the environmental quality objective of Sustainable Forests was not met. It was assessed that it would be very difficult to meet the national objective by 2010 even if further action was taken. Third, based on quantitative and qualitative analysis, to assess how much of additional protected areas, nature conservation management, and restoration are needed for biodiversity conservation with different levels of ambition. The result was that to reach the long-term policy goal formulated in SOU (1997a,b), habitat restoration and spatial planning of landscapes and regions were needed. Although summarised in Swedish (Angelstam et al. 2010), this assessment is of general interest for an international audience. A detailed review and discussion of the details of this process and what it may deliver on the ground can be found in Angelstam et al. (2011), also including the policy formulation process itself.

The aim of this paper is to make an assessment of the chain of events from the first nature conservation strategy (Naturvårdsverket 1991) as well as the formulation of short-term and long-term targets for formal protection and voluntary set-aside of forests in Sweden (SOU 1997a,b) to the outcomes of the policy implementation process in terms of its outputs and their consequences (sensu Rauschmayer et al. 2009, but without considering of the policy process itself). This article thus (1) addresses how ecological knowledge was used as part of the policy process to formulate qualitative and quantitative performance targets or norms (Lammerts van Buren and Blom 1997), and how policy implementation was carried out in a hierarchical manner at national, regional and local levels (e.g., Carlsson 2008), describes the consequences in terms of (2) the increased area of formally protected and voluntarily set-aside forests in relation to short-term interim targets. Using a quarter of Sweden as a case study we also attempt to assess (3) the functionality of Sweden's main natural forest and cultural woodland habitats, and (4) the conservation planning process among land managers representing different land owner categories and responsible government units in relation to the policy.

2 Methods

2.1 Policy implementation process

The formulation of a new forest policy in the early 1990s (Regeringens proposition 1992/93:226) triggered a long sequence of activities to translate policy into practice via strategic, tactical and operational steps, and finally, tangible consequences on the ground. To describe the policy implementation process concerning protected areas we reviewed documents and reports, and interviewed eight key staff members within government agencies for forest and conservation at national and regional levels. All interviews were open-ended, qualitative research interviews (Kvale 1996, Kvale and Brinkman 2008). The paper also builds on our own participatory observations of these processes as we collectively have taken part in several of the steps (e.g., see Angelstam and Andersson 2001, Angelstam et al. 2010).

We divided the process of implementing Swedish biodiversity conservation policy by forest protection into four phases: (1) interpretation of policy content and norms for implementation in planning and practice, and the subsequent hierarchical conservation planning process in terms of (2) formulation of long-term strategic quantitative targets regarding the amount of protected forest areas in Sweden, (3) development of tactical planning in terms of selecting different types of protected areas, and (4) operational execution of these plans by creating protected areas, including the allocation of funding to acquire forest land for conservation, or to pay compensation to land owners for the limitations in land use that follows from area protection.

2.2 Outcomes on the ground

2.2.1 Protected area development

We compiled data about the amount of protected areas presented in official publications from the Swedish Environmental Protection Agency and the Swedish Forest Agency, and also requested additional data from these government agencies. Data is presented both for the period 1991-97, i.e. before the short-term interim target for protected forests was formulated, and for the period of new policy implementation 1998-2010.

2.2.2 Analyses of habitat network functionality

We analysed habitat network functionality in south-central Sweden. The study area covered 145,000 km^2 and included all Swedish boreal and hemiboreal ecoregions (Fig. 1). The extent to which the land-cover proportion of formally protected and voluntarily set aside forests is functional for given species with particular life history traits (e.g., Angelstam et al. 2004b) depends on the quality and size of constituent habitat patches and their spatial configuration (e.g., Lafortezza et al. 2005). Given the existing knowledge about the interconnectedness and functional links for species, habitats and processes in boreal forests (e.g., Korpilahti and Kuuluvainen 2002, Angelstam and Kuuluvainen 2004, Angelstam et al. 2004c), rapid assessment using estimator-surrogate data such as habitat types (sensu Margules and Sarkar 2007) is possible. Habitat suitability modelling is such a tool (Scott et al. 2002). This requires (1) digital spatial data of the land covers of interest, (2) knowledge about focal species' habitat requirements, and (3) suitable spatial modelling algorithms (Store and Jokimäki 2003).

We used two land cover data bases for year 2000: the dataset produced by the Swedish University of Agricultural Sciences (Reese et al. 2003), derived using a combination of remote sensing of satellite scenes and data from the Swedish National Forest Inventory (kNN-Sweden), and the Land Cover Data (SMD) from the National Land Survey. The SMD originates from the EU CORINE land cover programme (Engberg 2002).

Historically, habitat networks in a given landscape were maintained by natural and anthropogenic disturbance regimes. Natural disturbance regimes in boreal forest can be divided into three broad types of forest dynamics (e.g., Angelstam and Kuuluvainen 2004). These are (1) gap dynamics where regeneration of shade-tolerant trees (e.g., Norway spruce *Picea abies,* H. Karst.) takes place in small patches (i.e. gaps) created when one or a few trees disappear from the canopy because of mortality, (2) succession dynamics related to large-scale disturbance caused by high intensity fire, wind throw or insect outbreaks, often favouring deciduous trees in early and mid successions, (3) cohort dynamics with partial loss of shade-intolerant trees (e.g., Scots pine *Pinus sylvestris,* L.) caused by low intensity fires. In addition, biodiversity is linked to cultural landscapes with a mosaic of forest, wooded grasslands, large trees and agricultural land which are mainly formed by (often traditional) anthropogenic disturbance regimes (Sjöbeck 1927, Erixon 1960).

The focal or umbrella species approach (Lambeck 1997) is based on the idea that conservation of specialised and area-demanding species can contribute to the protection of many less demanding co-occurring species (Roberge and Angelstam 2004). Empirical studies have confirmed that this is a useful approach (Roberge et al. 2008, Roberge and Angelstam 2006, 2009; see also Rompré et al. 2010). Habitat suitability index models were built for umbrella species in three main steps using raster land cover data and GIS (e.g., Store and Jokimäki 2003). First, the land cover types at the raster pixel level were selected in the digital spatial database to mirror the habitat selection of the focal species. Second, stands which provide sufficient amount of the relevant vegetation type necessary to meet the requirements of focal species individuals were identified. Finally, tracts with concentrations of suitable habitat that satisfy species-specific critical thresholds for the occurrence of a local population were identified. Focal species for older Norway spruce dominated forest, deciduous forest, old Scots pine forest, as well as for forest-field edge as a proxy for cultural woodlands, and relevant parameter values for modelling, were selected according to Angelstam et al. (2003b; see Table 1).

2.2.3 Planning processes among forest owner categories

The operational spatial planning process to implement biodiversity conservation policy on the ground was studied through qualitative interviews that followed Kvale (1996), Kvale and Brinkman (2008) and Ryen (2004). We focused on the bottom level of the conservation planning process, operational forest planning, and through this perspective connected to higher levels (Sabatier 1986, Lundqvist 1987). The interview manual focused on planners' understanding, capacity, and willingness to act related to landscape ecological planning and collaboration among stakeholders (Lundqvist 1987). The interviews were semi-structured with mainly open-ended questions. Some more general questions were followed by several specific questions to identify the strategy, and capacity for landscape planning. The interviewees were given full freedom to express themselves. The interviews were transcribed and analysed with qualitative methods to ensure that the results should be thoroughly supported in empirical data (Glasser and Strauss 1967, Kvale 1996, Ehn and Löfgren 2001, Ryen 2004).

All 25 interviewees were responsible for forest or conservation planning and were selected from the following categories: (1) public, state forest, industrial private and non-industrial private forest land owner categories identified using a national

GIS database showing the different types of forest land ownership (Wennberg and Höjer 2005); (2) organisations and businesses making forest management plans (e.g., forest owner associations, forest industries and forest consultancy bureaus); (3) municipalities; (4) forest agency districts; (5) county administrative boards, i.e. regional government agencies; (6) other actors mentioned by groups 1-5.

3 Results

3.1 The policy implementation process in Sweden

3.1.1 Interpretation of policy

Already in the early 1990s the principle that not only the state was responsible for investment in environmental and nature protection, but also the forest sector itself, was established. Analogous to the polluter pays principle, governance and conservation of natural resources and biological diversity was expected to be a normal part of forestry (Jordbruksutskottets betänkande 1990/91). During the 1990s this was further elaborated in a series of policy documents. In a government bill from 1990, reflecting a strong Swedish and Fennoscandian species-centred tradition, it was stated that plant and animal communities should be conserved in a way that maintains viable populations of all naturally occurring species and under natural conditions (Regeringens proposition 1990/91:90). This was continued with a policy addition aiming to secure the productive capacity of all forest land and to increase the protection for threatened species and different types of habitats (Regeringens proposition 1992/93:226). In accordance with the principle of representation of conservation areas by ecoregions, the nature conservation discussion concerning forest was divided in 1991 between productive forest within and below the mountain forests (*fjällnära skog* in Swedish; see SOU 2009:30). Moreover, the natural functions and processes in forest ecosystems should be maintained (Regeringens proposition 1997/98:145). The environmental quality objective Sustainable Forests, and its four interim targets (of which one focused on protected areas), has a strong focus on biodiversity (Regeringens Proposition 1997/98:145, 2000/01:130).

To conclude, the Swedish policy pronouncements capture the definitions of biodiversity and conservation well. Science-based biodiversity conservation thus emerged gradually. This is clearly an adaptation to the internationally agreed goals of the Convention of Biological Diversity that was established in the early 1990s (CBD 1992). The environmental objective of the Swedish forest and environmental policy pronouncements can be interpreted as having three key words and phrases concerning biodiversity conservation. These are "*all*", "*naturally occurring species*" and "*viable populations*".

Firstly, "*all*" refers to the interpretation that not only generalist species should be maintained, but also specialized species, which often have high demands on the habitat area and its qualities. Complementing the focus on red-listed species, the umbrella species concept (Lambeck 1997, Roberge and Angelstam 2004) was accepted as a concept that determined the kinds of species that could be used to formulate quantitative conservation targets (SOU 1997a).

Secondly, the term "*naturally occurring species*" links to the notion of representativeness, namely that networks of protected areas should represent the biological variation in a given region (Austin and Margules 1986, Scott et al. 1993). Sweden is a country with several types of natural forests (Nordic Council of… 1983) and cultural woodland regions (Sporrong 1996) with a wide range of habitats holding different species pools, all of which need to be represented when designing green infrastructures for biodiversity conservation, and thus in the formulation of conservation targets.

Thirdly, the term "*viable populations*" refers to population ecology in the short term and population genetics in the long term. Viability means that a population should be able to persist for a long time. Species whose individuals are small are likely to require less area than large-sized species to persist in viable populations. However, while the policies and guidelines on biodiversity are reasonably explicit, it is it is not clear at which spatial scales species conservation shall apply: in each municipality, county, natural region, or at the national level? This leaves room for actors with different interests and power to interpret policies differently.

3.1.2 Hierarchical conservation planning

The policy implementation process to conserve biological diversity followed the principle of hierarchical planning with strategic, tactical and operational planning in several steps (e.g., Sundberg and Silversides 1996). The first assessments and plans toward systematic conservation planning were developed in the early 1990s (Naturvårdsverket 1991, 1992). Later a quantitative gap analysis was done for each forest region, thus considering representativeness (SOU 1997a,b). It built on the fact that conserving viable populations requires sufficiently large amount of suitable habitat with adequate quality distributed in the landscape so as to form functional networks (Taylor et al. 1993, 2006). This corresponded to the strategic planning step, which was followed by the development of a system to prioritise areas for protection (Naturvårdsverket and Skogsstyrelsen 2005). Finally, tactical plans based on habitat network functionality criteria were made at the level of county administrative boards, followed by operational planning in the form of designation of protected areas.

3.1.2.1. Regional gap analysis

The purpose of a gap analysis is to estimate how much of different habitats remain in different regions compared to the historic potential (Dudley and Parish 2006, Scott et al. 1993, Krever et al. 2009). SOU (1997a,b), summarised by Angelstam and Andersson (2001), took the gap analyses concept one step further by defining also the extent to which there were gaps in the amount of habitat to maintain viable populations of naturally occurring species.

A short ABC for a quantitative gap analysis (Angelstam and Andersson 2001) includes the following three steps (Table 2). The first is to estimate the historical area of different forest habitats by inventories in a similar region under reference conditions (A). SOU (1997a,b) used the pre-industrial natural forest and cultural woodland as a baseline. By comparing (A) with estimates of the current quantities of various forest types (B), one can get an idea of how representative different habitats are today. Representativeness is simply a measure of the difference between A and B, or the proportion of the original conditions that remains in relation to what species have adapted to. Finally, with knowledge about the proportion out of the area of a particular natural forest environment required for retaining a viable population (C), one can estimate the areas of various representative forest types needed to maintain viable populations of all species. The actual gap analysis is then based on the difference between B and A×C, where a negative value indicates a gap in the area of habitat, and thus the need of restoration and even re-creation of habitats. The realization that there are extinction thresholds for how much habitat loss specialized species can withstand without losing their viability (e.g., Andrén 1999, Bender et al. 1998, Fahrig 2001, 2002, Angelstam et al. 2004c, Rompré et al. 2010, Angelstam et al. 2011) is central for the understanding of the need for both short and long-term goals to conserve biological diversity.

Focusing on the role of protected areas for forest biodiversity conservation, Liljelund et al. (1992) pioneered attempts to formulate area targets for forest protection, and Nilsson and Götmark (1992) made analyses of representation of protected areas for different types of land cover. The conclusions were that the area of protected forests needed to increase, and that there was a severe under-representation of more productive site types. Realising the need to maintain functional habitat networks, the Swedish Environmental Advisory Council commissioned a study in 1996 on how much of different forest habitat types with high conservation values should be set aside in the short and long term (SOU 1997b). The 1997 regional gap analysis was based on analyses of 14 different Swedish forest habitats below the mountain forest region, of which 12 represented natural forest types, and two represented cultural woodlands. Based on reviews of extinction and fragmentation thresholds, and species' requirements, a 20% rule of thumb was employed in the Swedish regional gap analysis (SOU 1997a, b, Angelstam et al. 2011). The need for forest protection was divided into long-term and short-term goals (Table 3).

By incorporating contemporary knowledge about forest ecology, forest history and conservation biology, this study concluded that in the long-term (~50 years), depending on the composition of different forest habitats and forest management practices in different Swedish ecoregions, 8-16% of forest landscapes should consist of functional networks of protected forest habitats of various kinds (SOU 1997b, Angelstam and Andersson 2001). The analysis thus suggested a substantial increase of protected areas below the mountain forest compared to the 0.8% that were protected in 1996. As a consequence, a short-term interim target was formulated by the government, which stated that by the end of 2010 the amount of formally protected and voluntarily set aside forests should increase by 400,000 and 500,000 ha, respectively (Regeringens Proposition 1997/98:145, 2000/01:130). These 900,000 ha correspond to 4.1 %-units increase in the conservation proportion out of all Swedish productive forests.

3.1.2.2 Tactical spatial planning

After completion of the regional gap analysis, the implementation process proceeded by starting to develop spatial plans to optimise functionality of forest habitat networks at the county level (e.g., Länsstyrelsen Östergötland 2007). The next landmark became the national compilation of high conservation value forests (Wennberg and Höjer 2005), and analysis of the location of core areas for forest protection (Naturvårdsverket and Skogsstyrelsen 2005). In contrast to the regional analysis which distinguished only four broad forest regions, this tactical analysis was spatially explicit, i.e. based on national and spatially explicit inventories of natural forest values, including WKH inventories on private and company-owned land and state forest inventories. The spatial planning strategy pronounced how protected area candidates should be selected for formal protection. Primarily the biological value of the area should be considered, including both the structure and species composition of the forest itself as well as its connectivity (landscape context) to other high value natural forests. A second criterion for formal protection was whether or not the site satisfied social and cultural interests. Finally, the extent to which the protection was practical was considered. The need for dialogue with forest land owners was also stressed as an important component. In 2006, the County administrative boards and the Swedish Forest Agency subsequently formulated regional county level strategies, which included detailed spatial analyses.

3.1.2.3 Operational protection

To facilitate the implementation of biodiversity policy, seven counties performed, commissioned by the Government in 2005, a pilot project during two years. The aim was to develop regionally adapted landscape strategies, i.e. working arrangements and planning processes for conservation and sustainable use of natural resources from a holistic and cross-cutting perspective at a local landscape level (Ihse and Oostra 2009). The seven pilot areas ranged from the mountains to regular managed forests in urban and rural areas. The areas also represented different phases in the development of collaboration, from recently initiated local cooperation to well developed collaboration based on ecological knowledge on biological diversity and committed players. As a result a handbook was produced (Naturvårdsverket 2010a). Similarly, the Swedish Forest Agency summarised its experiences (Jonegård 2009).

In the first evaluation of the implementation of the 900,000 ha area interim target for forest protection (Regeringens Proposition 2004/05:150) the government deemed that it would be difficult to reach it by the end of 2010, but also that this interim target should not be changed. Also Miljömålsrådet (2007) stressed the need for intensified activities to reach the area target. In line with this, Statskontoret (2007) proposed that the government-owned Sveaskog Co. should offer compensation areas for an estimated 60,000 ha of productive forestland with identified conservation values on land belonging to industrial forest owners. During 2008 the Swedish Environmental Protection Agency and Sveaskog Co. agreed that about 70,000 ha of Sveaskog holdings, most of which was already set aside as voluntary protection, should be set aside as nature reserves without economic compensation to the company. Later, pressure to speed up the area protection process prior to the parliament elections in autumn 2010 forced some county administrative boards to primarily establish protected areas on forest company land to reach the interim area target. The reason was that this was a much easier and faster solution than negotiating with a large number of non-industrial private forest owners. These two processes implied that county administrative boards had to abandon their spatial planning of protected areas.

They exemplify how economical and political circumstances may overthrow a well elaborated planning process.

3.2 Development of the amount of protected areas in Sweden

There are five kinds of formally protected and voluntary set aside areas in Sweden (Table 4). They can be divided into areas formally protected by law (national parks, nature reserves, biotope protection areas and conservation agreements), and voluntarily protected areas.

3.2.1 Productive lowland forests

According to the first systematic review of formally protected areas (Naturvårdsverket 1992), about 0.5% of the productive forests below the mountain forest region was formally protected in 1991. By 1997, 0.8% (174,000 ha) of the productive forest was formally protected (SOU 1997b). It was further estimated that about 4% of productive forests had high conservation value. From 1999 to 2006, almost 150,000 ha of forests were converted from industrial forestry to biodiversity conservation areas, including about 116,000 ha as nature reserves, 13,000 ha of habitat protection areas and 18,000 ha of conservation agreements (Statskontoret 2007). During the period 1999-2006 the average size of created nature reserves was 215 ha, ranging from 75 ha in Blekinge County in the south to 842 ha in Norrbotten County in the north (Statskontoret 2007). By the end of 2008, the forest protection figures had increased to 206,500 ha nature reserves, 16,500 ha habitat protection areas and 21,500 ha of conservation agreements (Prop. 2008/09:214 page 42). In other words 61% of the interim target for formal protection in the short-term had been reached 2 years before the 2010 deadline. To speed up the process of reaching the interim target, the government reserved in 2010 up to 100,000 ha productive forest land from Sveaskog Co. to be transferred to the state for use as a pool for forest land replacement when creating protected areas on private land (Regeringens proposition 2009/10:169). However, the work to formally delineate and designate the areas as protected still remained to be done. By the end of 2010, 80% of the interim target for formal forest protection had been reached (Fig. 2).

The figures on voluntarily protected areas are less precise than the formally protected areas. Voluntary set-aside of forest began in the early 1990s. By 1998 the area of voluntarily protected forests with conservation values was estimated at 230,000 ha below the mountain forest region (Skogsstyrelsen 1998a, b). Ten years later, in 2008, the Swedish Forest Agency (Skogsstyrelsen 2008:6) reported that about 936,000 ha was voluntarily set-aside for conservation below the mountain forest region. Skogsstyrelsen (2008:7) estimated that 72-80% (i.e. 674-749,000 ha) of the voluntary set-asides actually had significant nature conservation values. The numerical interim target of 500,000 ha voluntarily set aside forest was thus probably reached by the end of 2010. Presently the plan is that after 2010 the total area of voluntarily set aside forest will not increase anymore, but a continued exchange of forest areas with low conservation values for areas with higher conservation value is expected.

All in all, from 1997 to 2006 the proportion of formally protected productive forests below the mountain forests increased from 0.8% to 1.4%, and the voluntary set-asides increased from about 1.4% to about 3.2%. The total area of formally protected and voluntarily set aside areas outside mountain forests thus rose from 2.2% in 1997 to 4.6% in 2006. By the end of 2010, these figures had increased to 2.6% and 3.3%, respectively, i.e. in total 5.9%. The increase in formal protection and voluntary set-asides for the period 1991-2010 is summarised in Fig. 3.

3.2.2 Mountain forests

The forests along the Scandinavian mountain range have been treated as a special case during the policy process. This mountain forest region covers 3 million ha of which 1.5 million ha count as productive (SOU 2009:30) and is dominated by stands with low standing volume. It represents one of the last large areas with natural and semi-natural forests left in the European Union. According to Naturvårdsverket (1992), 265,000 ha were in *Domänreservat* (i.e. state forest company protected areas), and additionally 325,000 ha were in nature reserves and national parks, thus amounting to 590,000 ha (38%) with formal protection. According to SOU (1997b) and Naturvårdsverket (1997) a total of about 660,000 ha (~43%) of the mountain forests were formally protected in 1997. At present 106,000 ha of mountain pine forest, 511,000 ha mountain mixed coniferous and 32,000 of mountain spruce forest or in total ~42% is protected (SCB 2009). Skogsstyrelsen (2008:6) reported that in addition about 197,000 (13%) ha was voluntarily set-aside in the mountain forest region. However, knowledge of the existing conservation values was poorer in the mountain forest, but in general both the conservation value and size of set-aside stands were larger than in other forest regions. Summarising, 55-56% of the mountain forest region's productive forest is currently formally protected or voluntary set-aside for conservation purposes.

3.3 Case study: Analyses of habitat network functionality

On average 15% of the pixels belonging the four different forest habitats formed functional habitat networks that satisfied the requirements of the selected umbrella species (Fig. 4). However, there were significant regional differences among the four forest habitats in the different boreal ecoregions (Fig. 4). In general, the functionality of old spruce forest was highest (15-42%) among the four forest types, especially in the mid and south boreal ecoregion. The proportion of functional old pine forest was highest (42%) in the north boreal ecoregion and considerably lower (5-14%) in the three other ecoregions. Regarding old deciduous forests, the highest percentage of functional networks occurred in the hemiboreal forest ecoregion (21%), where it was two to four times as high as in the other ecoregions. Hence, in general, habitat network functionality for coniferous forests was better than for deciduous forests. Finally, the functionality of forest-field edge habitat was generally very low (0-11%). Overall, only a small proportion of the four forest habitats of high conservation value were functional for demanding focal species.

3.4 Case study: Planning processes among forest owners

The Swedish model for biodiversity conservation is built on a shared responsibility among landowners, the forest industry and the government. Another backbone is the principle of each sector's responsibility for the environment, with focus on the activities within each sector (see Regeringens proposition 1990/91:90). However, according to the interviews made with 25 forest and conservation planners in the same study area as used for spatial modelling, we could not trace this shared responsibility at the landscape or regional level. In addition, no single stakeholder claimed they shouldered a "full territorial" responsibility for conservation planning in an area except their own forest. The Swedish Forest Agency claimed responsibility for biodiversity conservation in forests. However, their work was focused mainly on identification of red-listed species and to some extent specific habitats, and they did not perform advanced spatial analyses. The county administrations claimed a responsibility for protected areas in the county. Their work was also mainly connected to red-listed species, as well as habitat protection. Based on national level strategies, each county administration developed a county level strategy as a base for formal forest protection. However, neither the county administrative boards nor the forest agency provided any support to spatial planning for forest planners on the ground.

Foresters stated that they experienced the forest policy from the early 1990s - which equalled ecological and economical objectives - as a shock but subsequently an understanding and acceptance for the equalled objectives have developed. Collaboration among conservation planners and stakeholders concerned mainly identification of red-listed species and to a lesser degree identification of specific habitats, but not habitat requirements for umbrella species, or any other species in a quantitative manner. None of the interviewed organisations expressed knowledge about how much habitat different species required or about the long term success of their conservation efforts. Sveaskog Co. had experience and knowledge in landscape ecological planning to create functional habitat networks in landscapes and ecoregions on their own land using their Ekopark concept (Angelstam and Bergman 2004). There was, however, no general collaboration that aimed at spatial planning of functional habitat networks in areas spanning multiple owner categories. Other large industrial forest owners used landscape scale planning to some extent on their own land, but rarely collaborated with neighbours in this work. Participation or involvement of stakeholders in conservation was limited to information with the aim to avoid conflicts. This was mainly done in areas close to cities, used for recreation and close to where people lived and were the view could be affected by final fellings. The interviews showed that there were no efforts to involve the public in collaborative learning processes, to develop socially robust solutions for conservation or to develop a common knowledge base among different stakeholder groups. No conservation planner used an analytic approach to map all relevant stakeholders for consultations. Instead stakeholders were invited via newspaper ads, bills on information boards and invitations to people living in the affected areas.

4 Discussion

The conclusions regarding the need for protected areas in the long term made in Sweden in the late 1990s were a consequence of Swedish and international policies and targets, which were combined with results from scientific research about forest ecology and conservation biology. This means that society has taken a clear value-based stand in favour of evidence-based science regarding biodiversity conservation, which then allows for the use of knowledge about how much habitat species need in the policy implementation process (see Wilhere 2008). Following an evidence-based regional quantitative gap analysis that focused on the amount of habitat in each ecoregion, there was a straight chain of decisions from the short-term interim target for protected areas decided by the parliament, a government decision, strategies by governmental agencies, and to the regional administrations' tactical planning to mitigate habitat fragmentation through spatial planning, as well as operational planning for designation, management and restoration of formally protected forests. Additionally, forest owners voluntarily set aside stands. In order to promote efficient conservation results on the ground, it is important that these three levels are interconnected and that the data and analytical results of landscape planning reach the operative level in a usable format (e.g., Borgström et al. 2006). Tear et al. (2005) proposed five principles for setting conservation objectives: (1) state clear goals, (2) define measurable objectives, (3) separate science-based knowledge from the feasibility to apply it, (4) follow scientific method and (5) anticipate change. Our review of the process to implement the biodiversity conservation policy in Sweden shows that it was indeed consistent with these five principles.

Following policy statements to maintain viable populations of all naturally occurring forest species, ecologically and biologically founded strategic quantitative long-term forest protection targets were formulated based on a quantitative gap analysis for the country's main ecoregions (Table 3). The target group for the gap analysis was policy makers and strategic planners. The difference between the long term policy goal for protected areas based on the quantitative gap analysis regarding forests below the mountain forest region (on average 10% across all ecoregions) on the one hand, and what was protected in 1997 (approximately 0.8%) on the other, was very large. Hence, it was evident that the gap in the amount of protected areas needed to be filled by additional area protection including existing non-protected forests with high conservation value, which were estimated to about 5%. This corresponds to the short-term interim target of 900,000 ha for forest protection 1998-2010 (Regeringens Proposition 1997/98:145, 2000/01:130), and a long-term restoration target of an additional 4%, thus totally about 10%.

By the end of 2010 the short-term target (400,000 ha) for formal protection below the mountain region was reached to 80%, and the voluntary set-aside target (500,000 ha) was estimated to be reached, albeit with poorly known quality. To fill the gap for formal protection (80,000 ha), a pool of Sveaskog Co. land (100,000 ha) was made available. However, the economic value of this forest was estimated to be lower than average, and it is thus uncertain if it is sufficient to purchase the 80,000 ha missing to reach the short-term interim target. To conclude, while the political will might be there and the support provided by the Sveaskog was very important, the interim area target was not fully reached. Additionally, there are at least three caveats as to reaching the policy target in terms of maintenance of viable populations of all naturally occurring species in the long term.

Firstly, judging from estimates of the area of high conservation value forests, there is not much forest left with high conservation value below the limit of mountain forest to set aside for biodiversity conservation in addition to the 5.9% formally protected and voluntarily set aside forests as of the end of 2010. According to the estimates made in the 1997 gap analysis there was, below the mountain forest, about 3.2% unprotected productive forest with high conservation value. Additionally there was 0.8% already protected forest, and an estimated 0.9% was voluntarily set-aside. This makes a total of 4.9%. The difference of 1 percent unit suggests that also forests without high conservation value have also been set aside. Compared with the long-term estimated goal of 10% (Figure 3), the conclusion is that to realize the forest and environmental policy intentions, there is a need to restore additional habitats through various forms of nature conservation management, restoration and re-creation (Angelstam and Andersson 2001; see Table 3). In addition there is a growing need of management and forest restoration also within already protected areas, a need that will increase as forests with a lower initial habitat quality will be set aside in the future to meet the long term protection targets. This denotes a shift in the view of management of protected forests, and has caused considerable debate (Naturvårdsverket 2010b), but is consistent with the international discussion on landscape restoration (Mansourian et al. 2005).

Secondly, it is unclear how much of different forest biodiversity qualities the formally protected and voluntary set-aside areas actually provide. Habitat quality today, location relative to core areas of connectivity, and long term maintenance of the quality by renewal of habitats are three factors. In addition it is unclear to what extent the formally protected and voluntarily set aside areas are representative in terms of forest types; some types are likely overrepresented and others not fully covered (Nilsson and Götmark 1992). Research clearly indicates that, among other things due to small population sizes, edge effects and historical impact of forestry the formally protected and voluntary set-aside forests may not provide habitat that support viable populations in the long term. This applies specifically to the voluntary set-asides (Aune et al. 2005, Jönsson and Jonsson 2007, Hottola, 2009, Hottola and Siitonen 2008). It is also in many cases unclear for how long the commitment of voluntary set-asides will last (see Table 4). There is in other words, a great need for a deeper evaluation of the quality of and formally protected and voluntary set-aside areas as well as the extent to which the form functional habitat networks (Elbakidze et al. 2011).

Thirdly, one must assess the functionality of areas of different forest environments as habitat networks at the landscape and regional levels; in other words the spatial distribution and configuration of all these areas. The 5.9 % of Sweden's formally protected and voluntary set aside forest areas outside of mountain forests (as of 2010) form a sparse archipelago of often isolated habitat islands. The habitat network functionality for conservation of viable populations, given that constituent patches have high conservation value, need to be assessed with respect to (1) habitat islands' (i.e. patch) size, (2) how close together habitat patches of the same forest type are located, and (3) the characteristics of the surrounding landscape matrix. There is thus a need to understand the trade-off between establishing new protected forests area that need restoration and what can be achieved by increased nature conservation in the managed matrix (Craig and Mitchell 2000, Lindenmayer and Franklin 2002). On the other hand, there is a growing interest in intensified forestry to increased wood and bioenergy yields (Larsson et al. 2010). On the basis of the information provided for the State of Europe's Forests 2011, four major challenges for the sustainable forest management of Europe's forests have been identified (Forest Europe 2011) as being climate change, wood for energy, conservation of forest biodiversity and green economy. This implies major challenges in identifying the viable options for biodiversity conservation and critical ecological analysis of these options.

Thus, effectiveness in policy implementation as percent of a region and hectares in an area is one thing, while functionality in terms of providing habitat for viable populations is quite another (Carwardine et al. 2009). The case study exploring the functionality of four different networks of critically important forest habitats (old spruce, old deciduous, old pine and forest-field edge) reported here unfortunately shows that the functionality of habitat networks is not favourable. Additionally, the reported levels of functionality may still be overestimates. The forest data based on remote sensing used to describe habitat is thematically coarse and spatially uncertain especially at the finer scale (Reese et al. 2003, Manton et al. 2005). While for coarse habitat categories (e.g., managed forest age classes) and at larger spatial scales these data are quite reliable (e.g., Bach et al. 2006), they may overestimate the habitat quality and connectivity for more specialized organisms (e.g., species linked to old-growth forest).

Additionally, our interviews consistently showed that forest owners and planners did not plan for forest biodiversity conservation spatially across ownership borders with the aim to improve connectivity. It can also be noted that despite the fact that there are many different land owners in Sweden, there are few forest and conservation planners. Nevertheless, results from interviews with forest and conservation planners showed that they had positive attitudes to the conservation of biological diversity, but very limited knowledge and capacity to act effectively. This is consistent with studies of biodiversity conservation planning made using the same framework in another case study (Blicharska et al. 2011). There is thus opportunity to develop the shared responsibility that conservation is supposed to be built on according to Swedish policy. More or less all forest planners and some conservation planners were also skilled users of Geographical Information Systems. This means that tactical spatially explicit plans, adapted to the local context, such as land owners, forest type and site type could provide useful information, and potentially be integrated in forest and conservation planning processes. However, this requires a collaborative learning process among stakeholders to assure acceptable and socially robust solutions. An important task for a collaborative learning process is thus to improve the understanding of different stakeholders' opportunities, and the content of forest and conservation policies.

Long term biodiversity conservation requires a combination of maintaining existing conservation values, conservation management, restoration and re-creation of different forest habitats that all need to form sufficiently large and functionally connected networks that represent different ecoregions. This is in line with the programme of work on protected areas established by the Convention of Biological Diversity (CBD 2004). The international target for protected areas by 2020 was recently agreed on as 17% of all terrestrial habitats, with a clear reference to ecological representativity (i.e. the CoP 10 decisions, Nagoya 2010 (CBD 2010)). Conserving biological diversity spans a range of ambitions from presence of species in the short term, maintaining viable populations of all indigenous species in the long term to ecological integrity, and to social-ecological resilience (Angelstam et al. 2004d, Svancara et al. 2005). During the past 20 years in Sweden the focus has been to conserve species in the short term through the provision of small patches of protected forest areas, voluntary or formally. The long term goal to preserve all naturally occurring species in viable populations, according to Swedish forest and environmental policies is a much higher level of ambition (Angelstam et al. 2011). EU-level policies pronounce even higher levels of ambition such as ecological integrity and resilience (e.g., European Commission 2000, 2010, Kettunen et al. 2007). Increasing ambition levels of biodiversity conservation require increased amounts of habitat (Svancara et al. 2005, Angelstam et al. 2011). We agree with Rompré's et al. (2010) conclusion that management approaches that combines thresholds to maintain managed landscapes within their limits of natural variability is a promising avenue.

To conclude, the existing areas of high conservation value forests in Sweden are presently too small and too fragmented in relation to the current forest and environmental policy ambitions. Bridging this gap requires continued protection, management and restoration to create representative and functional habitat networks. This calls for the establishment of neutral fora and platforms for collaboration and partnership development to improve integration among different actors. The term 'integrated landscape approach' captures this (World Forestry Congress 2009).

5. Acknowledgements

This work was funded by grants from the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (FORMAS) to Per Angelstam. We thank Michael Andersson, Johan Bodegård, Erik Ederlöf, Erik Hellberg, Olle Höjer, Hans Ljungkvist, Rolf Löfgren, Jan Terstad and Erik Sollander for important insights into Swedish biodiversity conservation planning, and the interviewees for their time.

6. References

Andrén, H. 1999. Habitat fragmentation, the random sample hypothesis and critical thresholds. Oikos 84(2): 306-308.

Angelstam, P. 2003. Forest biodiversity management - the Swedish model. In: Lindenmayer, D. B., Franklin, J.F. (eds.) Towards forest sustainability, CSIRO Publishing, Canberra, and Island Press, Washington, pp. 143-166.

- 2004. Habitat thresholds and effects of forest landscape change on the distribution and abundance of black grouse and capercaillie. Ecological Bulletins 51: 173-187.

- & Andersson, L. 2001. Estimates of the needs for forest reserves in Sweden. Scandinavian Journal of Forest Research Supplement No. 3: 38-51.

-, Axelsson, R., Bush, T., Elbakidze, M. & Jönsson, I. 2012. Green infrastructures for forest biodiversity conservation in Sweden: policy creation, implementation process, consequences and prospects. Studia Forestalia Suecica, monograph 220.

- & Bergman, P. 2004. Assessing actual landscapes for the maintenance of forest biodiversity – a pilot study using forest management data. Ecological Bulletins 51: 413-425.

-, Boutin, S., Schmiegelow, F., Villard, M.-A., Drapeau, P., Host, G., Innes, J., Isachenko, G., Kuuluvainen, M., Mönkkönen, M., Niemelä, J., Niemi, G., Roberge, J.-M., Spence, J. & Stone, D. 2004d. Targets for boreal forest biodiversity conservation – a rationale for macroecological research and adaptive management. Ecological Bulletins 51: 487-509.

-, Dönz-Breuss, M. & Roberge, J.-M. (eds) 2004c. Targets and tools for the maintenance of forest biodiversity. Ecological Bulletins 51: 1-510.

-, Jonsson, B.-G., Törnblom, J., Andersson, K., Axelsson, R. & Roberge, J.-M. 2010. Landskapsansats för bevarande av skoglig biologisk mångfald: - en uppföljning av 1997 års regionala bristanalys, och om behovet av samverkan mellan aktörer. Rapport 4. Skogsstyrelsen.

- & Kuuluvainen, T. 2004. Boreal forest disturbance regimes, successional dynamics and landscape structures – a European perspective. Ecological Bulletins 51: 117-136.

-, Mikusinski, G., Rönnbäck, B.-I., Östman, A., Lazdinis, M., Roberge, J.-M., Arnberg, W. & Olsson, J. 2003a. Two-dimensional gap analysis: a tool for efficient conservation planning and biodiversity policy implementation. Ambio 32(8): 527-534.

-, Mikusinski, G., Eriksson, J.A., Jaxgård, P., Kellner, O., Koffman, A, Ranneby, B., Roberge, J.-M., Rosengren, M., Rönnbäck, B.-I., Rystedt, S. & Seibert, J. 2003b. Gap analysis and planning of habitat networks for the maintenance of boreal forest biodiversity in Sweden - a technical report from the RESE case study in the counties Dalarna and Gävleborg. Länsstyrelserna i Dalarna och Gävleborg, rapport 26 and 12.

-, Persson, R. & Schlaepfer, R. 2004a. The sustainable forest management vision and biodiversity – barriers and bridges for implementation in actual landscapes. Ecological Bulletins 51: 29-49.
-, Roberge, J.-M., Lõhmus, A., Bergmanis, M., Brazaitis, G., Dönz-Breuss, M., Edenius, L., Kosinski, Z., Kurlavicius, P., Lārmanis, V., Lūkins, M., Mikusinski, G., Račinskis, E., Strazds, M. & Tryjanowski, P. 2004b. Habitat modelling as a tool for landscape-scale conservation – a review of parameters for focal forest birds. Ecological Bulletins 51: 427-453.
Auld, G., Gulbrandsen, L.& McDermott, C. 2008. Certification schemes and the impacts of forests and forestry. Annu. Rev. Env. Resour. 33, 9.1 – 9.25.
Aune, K., Jonsson. B.-G. & Moen, J. 2005. Isolation and edge effects among woodland key habitats in Sweden: making fragmentation into forest policy? Biological Conservation 124:89-95.
Austin, M.P. & Margules, C.R. 1986. Assessing representativeness. In: M.B. Usher, Editor, Wildlife conservation evaluation, Chapman & Hall, London, pp. 45–67.
Axelsson, R., Angelstam, P., Elbakidze, M., Stryamets, N., Johansson, K.-E. In press. Sustainable development and sustainability: Landscape approach as a practical interpretation of principles and implementation concepts. Journal of Landscape Ecology.
Bach, M., Breuer, L., Frede, H.G., Huisman, J.A., Otte, A. & Waldhardt, R. 2006. Accuracy and congruency of three different digital land-use maps. Landscape and Urban Planning, 78(4): 289-299.
Baker, S. 2006. Sustainable development. Routledge, London and New York. 245 pp.
Bender, D. J., Contreras, T. A. & Fahrig, L. 1998. Habitat loss and population decline: a meta-analysis of the patch size effect. Ecology 79(2): 517-533.
Blicharska, M., Angelstam, P., Antonson. H., Elbakidze, M. & Axelsson, R. 2011. Road, forestry and regional planners' work for biodiversity conservation and public participation: a case study in Poland's hotspot regions. Journal of Environmental Planning and Management, 1-13, iFirst article.
Borgström, S. T., Elmqvist, T., Angelstam, P. & Alfsen-Norodom, C. 2006. Scale mismatches in management of urban landscapes. Ecology and Society 11 (2): 16. [online] URL: http://www.ecologyandsociety.org/vol11/iss2/art16/
Bush, T. 2010. Biodiversity and sectoral responsibility in the development of Swedish forestry policy, 1988-1993. Scandinavian Journal of History 35(4):471-498.
Bütler, R., Angelstam, P., Ekelund, P. & Schlaepfer, R. 2004. Dead wood threshold values for the three-toed woodpecker in boreal and sub-Alpine forest. - Biological Conservation 119: 305-318.
-, Angelstam, P. & Schlaepfer, R. 2004. Quantitative snag targets for the three-toed woodpecker Picoides tridactylus. Ecological Bulletins 51: 219-232.
Carlsson, L. 2008. Omstridd natur i teori och praktik. In: Sandström, C., Hovik, S. & Falleth, E.I. 2008. Omstridd natur. Boréa bokförlag, Umeå, pp. 33-59.

Carwardine, J., Klein, C.J., Wilson, K.A., Pressey, R.L. & Possingham, H.P. 2009. Hitting the target and missing the point: target-based conservation planning in context. Conservation Letters 2(1): 4-11.

CBD. 1992. The Convention on Biological Diversity. United Nations,

- 2004. Programme of work on protected areas. Available at http://www.cbd.int/programmes/pa/pow-goals-alone.pdf.

- 2010. Updating and revision of the strategic plan for the post-2010 period. Target 11. COP decision X/4.2.

Craig, J.L., Mitchell, N.D. & Saunders, D.A. (eds.) 2000. Nature Conservation 5. Nature conservation in production environments: managing the matrix. Surrey Beatty, Chipping Norton.

Currie-Alder, B. 2005. Unpacking participatory natural resource management: a conceptual framework to distinguish democratic governance from resource capture. Environments 33(2):1–16.

Domänverket. 1951. Naturvård å statens skogar. Stockholm.

Dudley, N. & Parish, J. 2006. Closing the gap. Creating ecologically representative protected area systems: a guide to conducting the gap assessments of protected area systems for the convention on biological diversity. Technical Series no. 24. Secretariat of the Convention on Biological Diversity, Montreal, Canada.

Ehn, B. & Löfgren, O. 2001. Kulturanalyser. Gleerups, Malmö.

Elbakidze, M., Angelstam, P., Andersson, K., Nordberg, M. & Pautov, Y. 2011 How does forest certification contribute to boreal biodiversity conservation? Standards and outcomes in Sweden and NW Russia? Forest Ecology and Management 262(11): 1983-1995.

Enander, K.-G. 2003 Skogsbrukssätt och skogspolitik 1950-2000. Report, No. 54, Department of silviculture, Swedish University of Agricultural Sciences. (In Swedish.)

Engberg, A. Produktspecifikation av Svenska CORINE marktäckedata, 2002. www.lantmateriet.se/upload/filer/kartor/kartor/SCMDspec.pdf

Eriksson, S. & Hammer, M. 2006. The challenge of combining timber production and biodiversity conservation for long-term ecosystem functioning - A case study of Swedish boreal forestry. Forest Ecology and Management 237(1-3): 208-217.

Erixon, S. 1960. Svenska byar utan systematisk reglering. Nordiska Museet, Stockholm.

European Commission. 1979. Council directive 79/409/EEC of 2 April 1979 on the conservation of wild birds. Council of the European Communities, European Centre for Nature Conservation.

- 1992. Council directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. Council of the European Communities, European Centre for Nature Conservation.

- 2000. Directive, 2000/60/EC of the European parliament and of the council of 23rd October 2000. Establishing a framework for community action in the field of water policy.

- 2010. Green infrastructure. European Commission Publications office.

European Landscape Convention. 2000. European Treaty Series No. 176, Council of Europe.

Fahrig, L. 2001. How much habitat is enough? Biological Conservation 100(1) 65-74.

- 2002. Effect of habitat fragmentation on the extinction threshold: a synthesis. Ecological Applications 12(2): 346-353.

Forest Europe. 2011. State of Europe's Forests. Ministerial Conference on the Protection of Forests in Europe, Liaison Unit, Oslo.

Glasser, B.G. & Strauss, A.L. 1967/2008. The discovery of grounded theory: strategies for qualitative research. Aldine Transaction, New Bruinswick and London.

Höjer, O. (ed.) 2009. Swedish nature conservation 100 years. Naturvårdverket, Stockholm.

Hottola, J. 2009. Communities of wood-inhabiting fungi: Ecological requirements and responses to forest management and fragmentation. PhD-thesis, Faculty of Biosciences, University of Helsinki.

- & Siitonen, J. 2008. Significance of woodland key habitats for polypore diversity and red-listed species in boreal forests. Biodiversity and Conservation 17: 2559-2577.

Ihse, M. & Oostra, S. 2009. Regionala landskapsstrategier - Ett rikt växt- och djurliv. En kunskapssammanställning – fallstudier. Rapport 5855, Naturvårdverket.

Jansson, G. & Angelstam, P. 1999. Thresholds of landscape composition for the presence of the long-tailed tit in a boreal landscape. Landscape Ecology 14: 283-290.

Jonegård, S. 2009. Skogsstyrelsens erfarenheter kring samarbetsnätverk i landskapet. Skogsstyrelsen, Rapport 9.

Jönsson, M.T. & Jonsson, B.G. 2007. Assessing coarse woody debris in Swedish woodland key habitats: Implications for conservation and management. Forest Ecology and Management 242: 363-373

Jordbruksdepartementet. 1974. Kalhyggen. Ds Jo 1974:2. Stockholm. 250 pp.

Jordbruksutskottets betänkande 1990/91: JoU30. Om en god livsmiljö.

Kettunen, M., Terry, A., Tucker, G. & Jones, A. 2007. Guidance on the maintenance of landscape features of major importance for wild flora and fauna. IEEP, Brussels, 114 pp. & Annexes.

Korpilahti, E. & Kuuluvainen, T. (eds.) 2002. Disturbance dynamics in boreal forests: Defining the ecological basis of restoration and management of biodiversity. Silva Fennica 36(1): 1-447.

Kortelainen, J. 2010. Old-growth forests as objects in complex spatialities. Area DOI: 10.1111/j.1475-4762.2010.00951.x

Kvale, S. 1996. InterViews: An introduction to qualitative research interviewing. Sage publications, Thousand Oaks.

- & Brinkman, S. 2008. InterViews: Learning the craft of qualitative research interviewing. Sage publications, Thousand Oaks.

Lafortezza R., Corry R. C., Sanesi G. & Brown R. D. 2005. Quantitative approaches to landscape spatial planning: clues from landscape ecology. WIT Transactions on Ecology and the Environment 84: 239-250.

Lambeck, R.J. 1997. Focal species: a multi-species umbrella for nature conservation. Conservation Biology 11 (4): 849-856.

Lammerts van Buren, E.M. & Blom, E.M. 1997. Hierarchical framework for the formulation of sustainable forest management standards. Principles, criteria, indicators. Tropenbos Foundation, Backhuys Publishers, AH Leiden, The Netherlands. 82 pp.

Larsson, S., Lundmark, T. & Ståhl, G. 2010. Möjligheter till intensivodling av skog. Slutrapport regeringsuppdrag Jo 2008/1885. Sveriges lantbruksuniversitet.

Lee, K.N. 1993. Compass and Gyroscope. Island Press, Washington, D.C.

Liljelund, L.-E., Pettersson, B. & Zackrisson, O. 1992. Skogsbruk och biologisk mångfald. Svensk Botanisk Tidskrift 86: 227-232.

Lindenmayer, D. & Franklin, J.F.F. 2002. Conserving forest biodiversity: a comprehensive multiscaled approach. Island Press.

Länsstyrelsen Östergötland 2007. Levande eklandskap i Östergötland – regional landskapsstrategi 2008-2015. Rapport 2007:22.

Lundquist, L. 1987. Implementation steering. An actor-structure approach. Studentlitteratur, Lund.

Mansourian, S., Vallauri, D. & Dudley, N. (eds.) 2006. Forest restoration in landscapes, beyond planting trees. Springer, New York.

Manton, M.G., Angelstam, P. & Mikusiński, G. 2005. Modelling habitat suitability for deciduous forest focal species - a sensitivity analysis using different satellite land cover data. Landscape Ecology 20: 827-839.

Margules, C. & Sarkar, S. 2007. Systematic conservation planning. Cambridge University Press, Cambridge.

MCPFE. 1993. Reslution H1. General guidelines for the sustainable management of forests in Europe. Helsinki.

Miljömålsrådet. 2007. Miljömålrådets uppföljning av Sveriges miljömål. De Facto 2007. Naturvårdsverket.

Miljömålsrådet. 2008. Miljömålen – nu är det bråttom. Naturvårdsverket.

Naturvårdsverket. 1982. Urskogar. Inventering av urskogsartade områden i Sverige. 1 Allmän del. SNV PM 1507.

- 1991. Naturvårdsplan för Sverige. En strategi för säkerställandearbetet. Naturvårdsverket, Solna.

- 1992. Skyddad natur 30 juni 1991. Naturvårdsverket. Solna.

- 1997. Skogsreservat i Sverige. Rapport 4707.

- 2010a. Arbetssätt för biologisk mångfald och andra värden i ett landskapsperspektiv. Rapport 6342.

- 2010b. Förslag till strategi för naturvårdande förvaltning av skogar och andra trädbärande marker i nationalparker, naturreservat och Natura 2000-områden. Remissversion 20100225.

- & Skogsstyrelsen. 2005. Nationell strategi för formellt skydd av skog. Naturvårdsverket, Stockholm and Skogsstyrelsen, Jönköping.

Nilsson, C. & Götmark, F. 1992. Protected areas in Sweden: is natural variety adequately represented? Conserv. Biol. 6: 232–242.

Nitare, J. & Norén, M. 1992. Nyckelbiotoper kartläggs i nytt projekt vid Skogsstyrelsen. Svensk Botanisk Tidskrift 86: 219–226.

Nordic Council of Ministers. 1983. Representative types of nature in the Nordic countries. Nordic Council of Ministers, Berlings, Arlöv. 60 pp + map.

Noss, R. F. 1990. Indicators for monitoring biodiversity: a hierarchical approach. Conservation Biology 4: 355–364.

Oldertz, C. 1959. Naturskydd och landskapsvård. In: Arpi, G. (ed) Sveriges skogar under 100 år. Part II: 649-658.

Pennanen, J. 2002. Forest age distribution under mixed-severity fire regimes – a simulation-based analysis for middle boreal Fennoscandia. Silva Fennica 36:

Rauschmayer, F., Berghöfer, A. Omann, I. & Zikos, D. 2009. Examining processes or/and outcomes? Evaluation concepts in European governance of natural resources. Environmental Policy and Governance 19: 159-173.

Reese, H., Nilsson, M., Pahlén, T. G., Hagner, O., Joyce S., Tingelöf, U., Egberth, M. & Olsson, H., 2003. Countrywide estimates of forest variables using satellite data and field data from the National Forest Inventory. Ambio 32(8) 542–548.

Regeringens proposition 1990/91:90. En god livsmiljö. Riksdagen, Stockholm.

- 1992/93:226. Om en ny skogspolitik. Riksdagen, Stockholm.

- 1997/98:145. Svenska miljömål. Miljöpolitik för ett hållbart Sverige. Riksdagen, Stockholm.

- 2000/01:130. Svenska miljömål – delmål och åtgärdsstrategier. Riksdagen, Stockholm.

- 2004/05:150. Svenska miljömål – ett gemensamt uppdrag. Riksdagen, Stockholm.

- 2007/08:108. En skogspolitik i takt med tiden. Riksdagen, Stockholm.

- 2008/09:214. Hållbart skydd av naturområden. Riksdagen, Stockholm. Riksdagen, Stockholm.

- 2009/10:170. En enklare plan- och bygglag. Riksdagen, Stockholm.

- 2009/10:169. Förändrat uppdrag för Sveaskog AB. Riksdagen, Stockholm.

Rompré, G, Boucher, Y., Bélanger, L., Côté, S. & Robinson, W.G. 2010. Conserving biodiversity in managed forest landscapes: The use of critical thresholds for habitat. Forestry Chronicle 86(4): 589-596.

Roberge, J.-M. &Angelstam, P. 2004. Usefulness of the umbrella species concept as a conservation tool. Conservation Biology 18(1): 76-85.

- & Angelstam, P. 2006. Indicator species among resident forest birds – a cross-regional evaluation in northern Europe. Biological Conservation 130: 134-147.

- & Angelstam, P. 2009. Selecting species to be used as tools in the development of forest conservation targets. In: Villard, M.-A. & B.G. Jonsson (Eds). Setting conservation targets for managed forest landscapes. Cambridge University Press, Cambridge. pp. 109-128.

- Angelstam, P. & Villard, M.-A. 2008. Specialised woodpeckers and naturalness in hemiboreal forests - deriving quantitative targets for conservation planning. Biological Conservation 141: 997-1012.

Rosén, B. 1953. Naturvård. Skid- och Friluftsfrämjandet. Landby & Lundgrens boktryckeri, Malmö.
Ryen, A. 2004. Kvalitativ intervju. Liber, Malmö.
Sabatier, P.A. 1986. Top-down and bottom-up approaches to implementation research: a critical analysis and suggested synthesis. Journal of Public Policy 6(1): 21-48.
SCB. 2009. Skyddad natur 31 dec 2009. Sveriges officiella statistik. Statistiska Meddelanden MI 41 SM 1001.
Scott, J. M., Davis, F., Csuti, B., Noss, R., Butterfield, B., Groves, C., Anderson, H., Caicco, S., D'Erchia, D., Edwards Jr., T. C., Ulliman, J. & Wright, R. G. 1993. Gap analysis: A geographic approach to protection of biological diversity. Wildlife Monographs 123:1-41.
-, Heglund, P.J., Morrison, M.L., Haufler, J.B., Raphael, M.G., Wall, W.A. & Samson, F.B. (eds.) 2002. Predicting species occurrences: issues of scale and accuracy. Washington DC: Island Press.
Sjöbäck, M. 1927. Bondskogar, deras vård och utnyttjande. Skånska folkminnen.
Skogsstyrelsen 1998a. Skogsvårdsorganisationens Utvärdering av Skogspolitiken. Skogsstyrelsen, Jönköping. Meddelande 1:1998. 103 s.
Skogsstyrelsen. 1998b. Naturskydd och miljöarbete. Skogsstyrelsen, Jönköping. Meddelande 6:1998.
- 2007. Fördjupad utvärdering av Levande skogar. Meddelande 4. Skogsstyrelsen, Jönköping.
- 2008. Skogsbrukets frivilliga avsättningar. Meddelande 3. Skogsstyrelsen, Jönköping.
Statskontoret. 2007. Skyddet av levande skogar. Rapport 2007:14.
SOU. 1997a. Skydd av skogsmark. Behov och kostnader. Statens offentliga utredningar 1997:98. Huvudbetänkande. Miljövårdsberedningen.
- 1997b. Skydd av skogsmark. Behov och kostnader. Statens offentliga utredningar 1997:98, Bilaga 4. Miljövårdsberedningen.
- 2006. Slutbetänkande av skogsutredningen. Mervärdesskog. Del 2. Utredningens underlag A. SOU 2006:81.
- 2009. Skog utan gräns? Betänkande från gränsskogsutredningen. Statens offentliga utredningar 2009:30.
Sporrong, U. 1996. Odlingslandskap och landskapsbild. Studier till kulturmiljöprogram för Sverige. Riksantikvarieämbetet, Stockholm.
Store, R. & Jokimäki, J. 2003. A GIS-based multi-scale approach to habitat suitability modelling. Ecological Modelling 169: 1-15.
Sundberg U. & Silversides CR (eds.) 1996. Operational efficiency in forestry. Kluwer Academic Publishers, AH Dordrecht, The Netherlands.
Svancara, L.K., Brannon, R., Scott, J.M., Groves, C.R., Noss, R.F. & Pressey, R.L. 2005. Policy-driven versus evidence-based conservation: a review of political targets and biological needs. BioScience 55(11): 989-995.
Säve, P.A. 1877. Sista paret ut. Svenska Jägarförbundets Nya Tidskrift 15: 70-86.
Taylor, P., Fahrig, L., Henein, K. & Merriam, G. 1993. Connectivity is a vital element of landscape structure. Oikos 68 (3), 571–572.

-, Fahrig, L. & With, K. 2006. Landscape connectivity: a return to the basics, in Crooks, K., Sanjayan, M. (Eds), Connectivity conservation. Cambridge University Press, pp. 29–43.

Tear, T.H., Kareiva, P., Angermeier, P.L., Comer, P., Czech, B., Kautz, R., Landon, L., Mehlman, D., Murphy, K., Ruckelshaus, M., Scott, J.M. & Wilhere, G. 2005. How much is enough? The recurrent problem of setting measurable objectives in conservation. BioScience 55(10): 836-849.

Timonen, J., Siitonen, J., Gustafsson, L., Kotiaho, J.S., Stokland, J.N., Sverdrup-Thygeson, A., Mönkkönen, M. 2010. Woodland key habitats in northern Europe: concepts, inventory and protection. Scandinavian Journal of Forest Research 25 (4): 309-324.

United Nations. 2010. Building bridges between the state & the people - an overview of trends and developments in public administration and local governance. United Nations development programme.

Vanha-Majamaa I., Jalonen J. 2001. Green tree retention in Fennoscandian forestry. Scandinavian Journal of Forest Research 16, Supplement 3: 79-90.

Vucetich, J.A. & Nelson, M.P. 2010. Sustainability: virtuous or vulgar? BioScience 60(7): 539-544.

Wennberg, S. & Höjer, O. 2005. Frekvensanalys av Skyddsvärd Natur (FaSN). Förekomst av värdekärnor i skogsmark. Rapport 5466, Naturvårdsverket.

Wiktander, U., Olsson, O. & Nilsson, S.G. 2001. Seasonal variation in home-range size, and habitat area requirement of the lesser spotted woodpecker (Dendrocopos minor) in southern Sweden. Biological Conservation 100(3) 387-395.

Wilhere, G. F. 2008. The how-much-is-enough myth. Conservation Biology 22: 514-517.

Wilson, E.O. (ed.) 1988. Biodiversity. National Academy of Science Press, Washington, DC.

World Forestry Congress, XIII. 2009. Buenos Aires, Argentina. Forest Development: A Vital Balance, Findings and Strategic Actions. Findings and Strategic Actions, se: http://foris.fao.org/meetings/download/_2009/xiii_th_world_forestry_congress/misc_documents/wfc_declaration.pdf

Table 1. Definitions of the land cover variables and parameter values used for modelling of the functionality of habitat networks of four coarse forest types. Evidence-based knowledge about representative focal species was used to select appropriate land cover data, define habitat themes, select sufficiently large patches and create rules for defining tracts in the landscape with a high probability of occurrence of local populations.

Coarse forest and woodland type	Focal species	Land cover data base	Definition of habitat theme and resource density using land cover data	Minimum stand size	Rules for creating tracts (% patches and neighbour-hood size)
Old spruce	*Picoides tridactylus* (L.)	k-NN Sweden (1))	Spruce and conifer mixed forest >70 years except for over 70% pine or deciduous forest over 70 years (3)	10 ha	25 % 4 km^2
Deciduous succession	*Aegithalos caudatus* (L.) and *Dendrocopos minor* (L.)	k-NN Sweden (1)	Deciduous forest over 40 years or mixed forest with minimum 20% deciduous > 40 years (4, 5)	7 ha	15 % 1 km^2
Old pine	*Tetrao urogallus* (L.)	k-NN Sweden (1): SMD (2)	1* pine older than 70 years; 0.8* conifer older than 70 years. k-NN Sweden and SMD: 0.5* pine and conifer mixed older than 40 and younger than 70 years or 0.5 * forest on mire (6)	200 ha	25 % 16 km^2
Forest-farmland edge	*A. caudatus* (L.) and *D. minor* (L.)	SMD (2) and topographic data base	Deciduous (SMD class 40), mixed (SMD class 48) forest in 200-m wide farmland buffer into the forest mask (4, 5)	1 ha buffered pixels	20 % 2 km^2

(1) k-NN (k-Nearest Neighbour), Reese et al. (2003); (2) SMD (Svensk MarktäckeData), Engberg (2002); (3) Bütler et al. (2004a,b); (4) Jansson and Angelstam (1999); (5) Wiktander et al. 2001; (6) Angelstam (2004)

Table 2. Summary of concepts associated to quantitative regional gap analyses concerning the proportion of a forest habitat or attribute that needs to be conserved (including protection, management and restoration) to maintain viable populations in an ecoregion.

Variable	Description
A	The amount of a particular forest environment which species have adapted to in the region[a]
B	Today's amount
A-B	Representation
C	Performance target or norm based on knowledge about the proportion out of the area of a particular natural forest environment required for retaining a viable population;
A*C	Long- term target for the amount of a particular forest environment
B - (A*C)	Gap (if the value is negative)

[a] in naturally dynamic boreal forest landscapes (Pennanen 2000), or traditional cultural landscape (Erixon 1960).

Table 3. Summary of results of the quantitative gap analysis concerning productive forests below the mountain forest in Sweden (SOU 1997:98, Bilaga 4, page 5). Using general threshold value of 20% as a target for the necessary amount of remaining habitat in the long term the following steps were taken: (I) individual assessment of 12 natural forest and 2 cultural woodland types according to their expected occurrence in the different ecoregions and (II) assessment of which of these forest types managed landscapes can deliver. The remainder (III) became the long-term target for set-aside of forests to maintain viable populations of naturally occurring species. This long-term target is satisfied by summing up (IV) the already protected area in 1997, taking into account (V) the nature values created by nature consideration and landscape planning in regular forest management, setting aside (VI) forests and woodlands with high nature values that were not protected, (VII) including the area of wooded grasslands of the cultural landscape, and finally (VIII) restore habitat by nature conservation management.

Item	Description	Average proportion and regional variation of productive forests below the mountain forest region in % of 218,800 km^2
I	Threshold rule of thumb (C in %; see Table 2)	≈20
II	Forest environments without needs for forest protection (%) (PG)	10 (4-12)
III	Long-term goal (%) with sub-components IV-XIII below	10 (8-16)
IV	Formally protected area 1997 (%)	0.8 (0.4-1.6)
V	Reduction of the need for forest protection due to functional nature considerations at the stand level (%) (PF/K)	0.9 (0.3-1.69)
VI	Short-term goals defined by existing unprotected forests with high conservation value (%) (NO and NS)	3.2 (1.9-3.5)
VII	Wooded grasslands in cultural landscape (%)	0.8 (0-2.2)
VIII	Restoration needs (%) (PF/K)	≈4 (3-11)

Table 4. Types of formally protected and voluntary set-aside areas (partly from Statskontoret (2007: 33)).

	Nature reserve and forested parts of national parks	Biotope protection	Conservation agreement*	Voluntary set-asides
Establishment	National park 1909 Nature reserve 1964	1998	1993	1991
Aim	Conserve and develop nature of high value for plants, animals and people	Conserve smaller terrestrial or aquatic habitat for threatened plants and animals	Conserve and develop qualities for biodiversity	A complement to formal protection to satisfy the 900,000 ha target with forest with as high conservation values as possible
Size	Usually >20 ha	<20 ha	variable	>0.5 ha
Area target 1998-2010	320,000 ha	30,000 ha	50,000 ha	500,000 ha
Decision by	County Administrative Board, Municipality	Forest Agency	Land owner and Forest Agency or Municipality	Land owner
Duration	Forever	Forever	30-50 yrs	unknown
Transparency	Full	Full	Full	Variable
Level of protection	No wood harvest, management only to maintain and develop conservation values	No wood harvest, management only to maintain and develop conservation values	Wood harvest refrained; does not regulate management, but objectives are formulated in the agreement	No protection. The forest owner may, however be committed by forest certification rules for one standard revision cycles (i.e. 5 years for FSC)
Right of seller	May sell, keep with economic compensation, or get compensation land. Hunting right can be kept.	Keep with economic compensation, and hunting rights	Keep with lower compensation according to agreement	Keep land.

* Skogsstyrelsen, Riktlinjer för Skogsstyrelsens arbete med naturvårdsavtal i skogen, protokoll nr 270, dated 2006-12-20; Naturvårdsverket, Vägledning för länsstyrelsernas arbete med naturvårdsavtal, 2007.

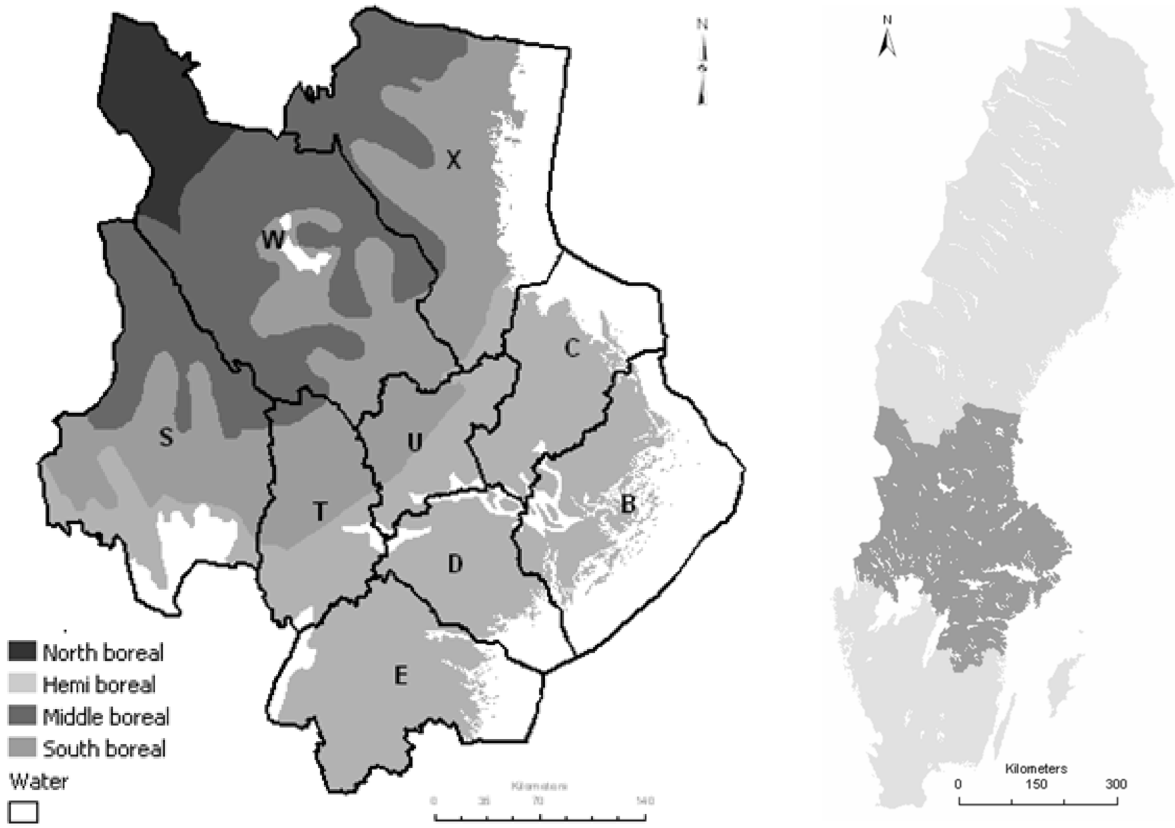

Figure 1. Maps of case study area (left, 144,877 km^2) in Sweden (right) to assess functionality of patches of three natural forest types and one cultural woodland type. The area was chosen to encompass four different boreal ecoregions, and covers nine counties Stockholm (B) (16,640 km^2), Uppsala (C) (12,006 km^2), Södermanland (D) (8,754 km^2), Östergötland (E) (14,624 km^2), Värmland (S) (21 923 km^2), Örebro (T) (9,685 km^2), Västmanland (U) (5,690 km^2), Dalarna (W) (30,405 km^2) and Gävleborg (X) (25,150 km^2) in south-central Sweden.

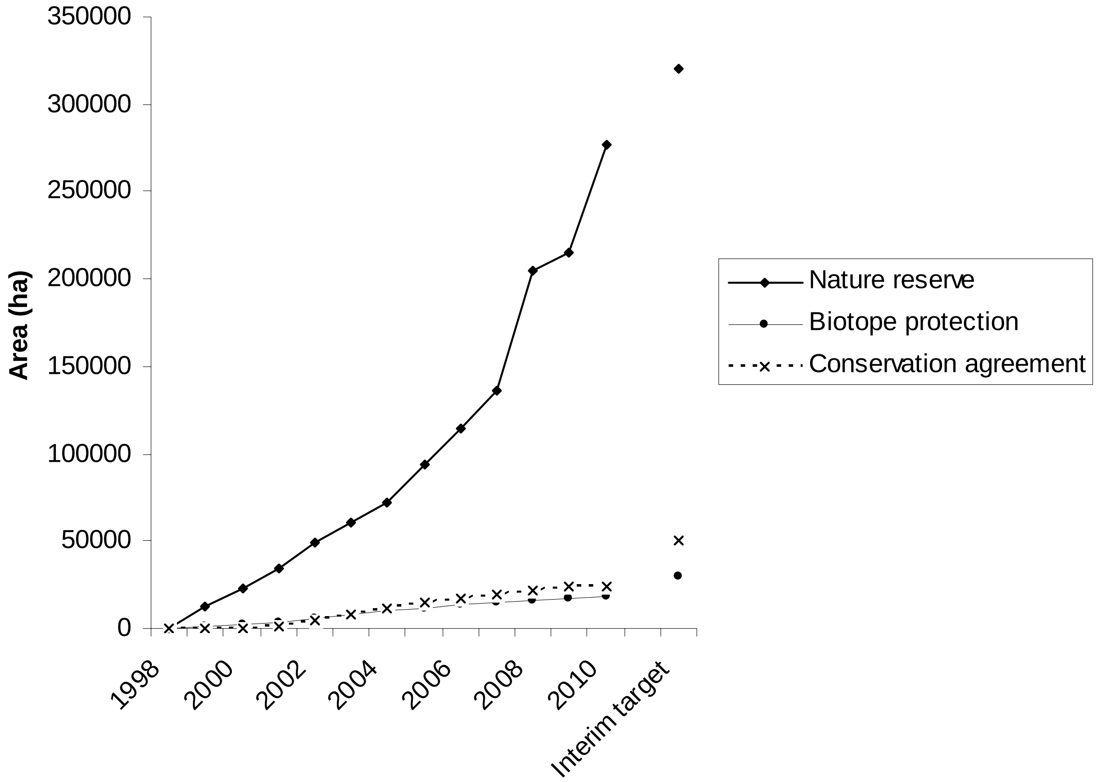

Figure 2. Development of the progress toward the interim target to be reached by the end of 2010 of formally protecting 400,000 ha in the form of nature reserves (87% fulfilled of 320,000 ha), biotope protection (60% of 30,000 ha) and conservation agreements (48% of 50,000 ha) in Sweden 1999-2010. Overall 80% of the 400,000-ha target was fulfilled by the end of 2010. Data from www.miljomal.nu (visited 2011-07-11).

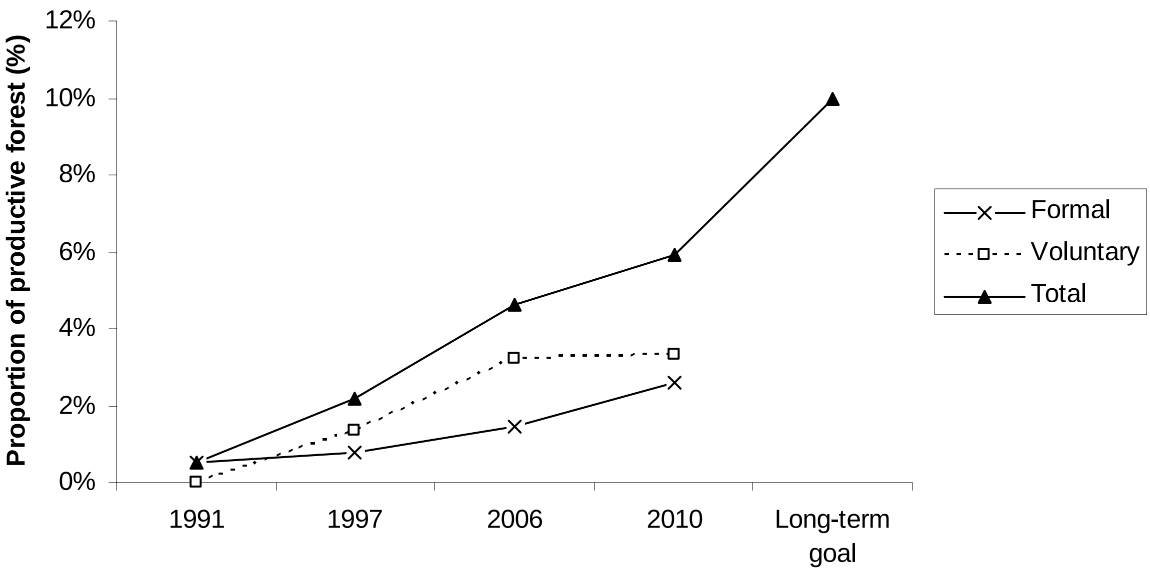

Figure 3. Development of the amount of formally protected and voluntarily set aside areas on productive forest land below the mountain forest in 1991 (Naturvårdsverket 1992:7), 1997 (SOU 1997a,b), 2006 (Regeringens proposition 2008/09:41), in 2010, and short-term goal according to SOU (1997a,b) with the objective of maintaining viable population of naturally occurring species. The voluntary set-asides from 2006 include forests with variable conservation values. Note that according to the estimates in the 1997 regional gap analysis there were 4.9% natural forest and cultural woodland areas. Hence, restoration is needed to reach long-term goal of 10%.

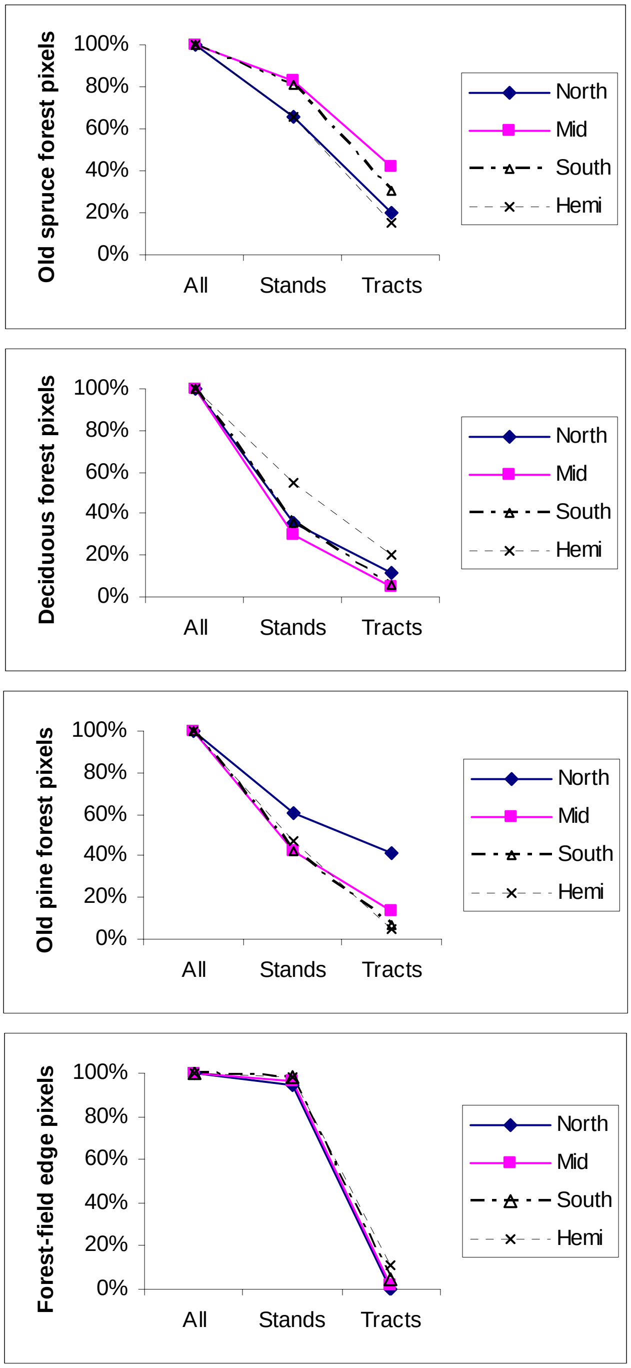

Figure 4. Results from modelling of habitat network functionality for four coarse forest types. The graphs show the proportion in percent of all 25x25 pixels of four coarse forest and woodland types which are located in sufficiently large stands for the focal species, and in functional tracts of habitat.