ESC-Strategy for Rational Operationalization of Forest Biodiversity Maintenance in Finland

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1 Seeking Sustainability: The Need for Comprehensive Approaches at Operational Level

Since the introduction of the idea of sustainability in the human use of natural resources, there have been profound changes in the operating environment of commercial forestry also in Finland. Despite that grand goals are set and different 'green policies' adopted, only seldom there is any consensus among different interest groups about the real contribution of these performances to sustainability of the activity itself. Evidently, the ultimate task for forestry related projects in the recently initiated multidiciplinary research program (Finnish Biodiversity Research Programme – FIBRE, Academy of Finland) is to construct firm prerequisites for this consensus to grow.

The purpose of this paper is above all to bridge the gap between societal demand for rationality in forest biodiversity conservation acts, and the point that natural state of ecosystems is often considered as the only acceptable model for nature conservation. At first we give a brief overview of the control mechanisms and regulations concerning relations between forestry and the maintenance of forest biodiversity in Finland. Regarding to different components of biological diversity, it seems that the defined goals of these control mechanisms are adequately extensive. Their operationalization, however, is unsatisfactory and also biased towards a certain subset of species due to some problems relating to the structure of managed forest landscape. These problems are discussed in their own chapters. By accounting also the social and economical considerations of sustainability, a feasible operational approach for forest biodiversity maintenance must base on both the spatial allocation of maintenance responsibilities and, depending on site-specific parameters in the target area, the clustering of species' resources. In the latter part of the paper we present a preliminary idea of a dynamic ESC-strategy for country-wide maintenance of biodiversity in managed forests. In the strategy forest species are divided according to the best achievable occurrence of their populations (E stands for 'Everywhere', i.e. species occur in practically all suitable managed forest habitats; S stands for 'Somewhere', i.e. species occur only in some proportion of suitable managed forest habitats; and C-species are able to occur almost exclusively only 'in Conservation areas'). This best achievable occurrence or 'ecological optimum for managed forests' is constrained by socio-economic aspects of sustainable forest management.

1.1 Present Regulative and Controlling Means

Particularly from the Finnish point of view, important milestones in an ongoing process of build-

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ing national biodiversity strategies and legislation concerning forests and forestry (Global Biodiversity Strategy 1992) have been the formation of national criteria and indicators for sustainable forestry (Criteria and indicators... 1995), and the recent reform of forest legislation. At present, the basis for conservation of biological diversity in managed forests is described in the tenth section of forest law by two regulations. First, there is a broader regulation that general prerequisites are secured for maintenance of biotopes characteristic of forest biodiversity. Despite of its vagueness, this regulation is meant to be representative of all facets of biological diversity in forests, since in the substantiation of the law its defined goal is to "secure sufficient living conditions for species that are adapted to different biotopes, successional stages and ecological situations" (Metsälaki perusteluineen 1997). Secondly, the section includes a list of important forest biotopes, whose characteristics must be preserved in the course of forest management and forest use. This latter regulation is substantiated as the minimum standard of biodiversity maintenance that is binding on all forest management.

The task of biodiversity maintenance is too complicated to be defined more precisely in the forest law, and the first regulation is rather a general principle. It is, after all, clearly a target-oriented legislative demand and, according to its substantiation, a comprehensive one. Due to its general nature this regulation obviously is not applicable in individual situations and in the enforcement there may be problems in defining responsible agents so that this regulation fulfills its function countrywide. Another danger arising both from the broadly outlined first principle and the idea of 'minimum standard' in the second regulation is that maintenance of biological diversity in managed forests may reduce merely to preservation of the listed biotopes.

Thus the forest law, as well as our national criteria and indicators for sustainable forestry set comprehensive regulative demands to maintain natural biodiversity, and regarding to their implementation, creation of certain structural characteristics into managed forests is presented as a suitable method. Originally these critical boreal forest characteristics were listed in the early 90's (e.g. Angelstam 1992, Esseen et al. 1992, Haila et al. 1994), and acknowledged among Finnish forest managers, when private forestry organization and forest companies recognized the need for an ecologically justified modification of forestry practices. The introduction of these structural components into forests take shape in clear guidelines for foresters concerning practices applied in individual management situations and, therefore, their purpose is to affect the forest structure primarily within stands. Besides that these instructions acknowledge the preservation of key-biotopes, they are also related to deciduous component in managed stands; mixed-age stands; retention trees of different species and types; different species and types of dead, decaying and charred wood; habitats of vulnerable and threatened species; and avoidance of all unnecessarily intense management methods in general. Regarding the maintenance of biological diversity especially at stand level, these approaches are quite valid in qualitative sense, because the deletion of those structural components by forestry has resulted in the most severe species losses in our managed forests. However, to be ecologically comprehensive at operational level and in concordance with regulative demands, forest management still needs further improvements. On the one hand there are questions concerning the scale of environmental heterogeneity. On the other hand this need for improvements is due to quantitative problems in distribution and abundance of species' resources. These problems are further discussed in next sections.

Landscape ecological planning has been conducted in state forests (Hallman et al. 1996), and it is a proper step towards a broader scale in the maintenance of biological diversity. However, by emphasizing the role of certain small-scale structural peculiarities (e.g. key-biotopes, corridors, 'stepping-stones') at the expense of forest structure per se at landscape level, the landscape ecological view of that particular approach deviates slightly from the one presented in this paper. Here the 'forest landscape structure' signifies the composition and configuration of successional stages as well as the distribution and abundance of species' resources at the landscape level.

1.2 The Scales of Environmental Heterogeneity in Managed Forests

The questions concerning relevant spatio-temporal scales of forest management are of crucial importance in biodiversity maintenance. Temporal and spatial scales of forest management are firmly fixed, economic optimization having been and being the most important determinant, and the forest landscape structure is thus unintentionally affected by the methods used in stand level forestry. These fixed scales have been applied prevalently, and together with the small patterned private ownership of forests they have led to a fine-grained, but structurally uniform forest landscape in Finland.

A forest, like all environments, is in itself heterogeneously patterned on multiple scales, referring to discontinuities in distribution of both biotic and abiotic conditions, and a meaningful examination of the ecological significance of environmental heterogeneity or patchiness must always rely on the organisms and ecological processes studied (e.g. Addicott et al. 1987, Kotliar and Wiens 1990, Dunning et al. 1992, Andrén 1994). Compared to natural forests, the characteristics of structural heterogeneity seem to be different throughout all spatial scales in managed forests (Hansson 1992, Kuuluvainen et al. 1994, Sjöberg and Ericson 1997, Uuttera 1998). Commercial forestry has decreased structural heterogeneity at stand level, and between forest landscapes, but has increased it within the landscapes. In other words, managed forest landscapes are, to some spatial extent, structurally heterogeneous as stands of different developmental stages are interspersed. When increasing the spatial scale of inspection, adjacent areas rapidly start to look similar because the variance in the proportions of developmental stages decreases rapidly with increasing scale due to the spatio-temporal fixation of forestry practices (Kurki 1997, Kurki et al. 1997). Reliable data on the natural state of large scale structural heterogeneity in Fennoscandian boreal forests are lacking (but see Syrjänen et al. 1994 for NW Russia), however it is quite evident that both the average grain-size of heterogeneity and variation in this grain-size would be much higher in natural situations. The decrease in variance of structural heterogeneity occurs in natural landscapes, too, but presumably on a much larger scale than in managed forests.

1.3 Quantitative Problems in Distribution and Abundance of Resources

Even without any spatial arrangements in the composition and configuration of managed stands, it is possible that, for many species, the distribution and abundance of essential resources will be improved at a landscape level due to qualitative improvements in forest structure at stand level. However, in spite of this possibility, there are at least three further problems concerning quantitative issues in relationships between resource distribution, landscape structure and species requirements. First, new instructions for forestry practices at stand level include several standardized precepts relating to the desired abundance of certain resources or structural characteristics. Even if those rule-of-thumb-values are intended against negative ecological effects of forestry, they are quite analogous to previous, economically justified standards. They may result in an altered but, nevertheless, homogeneous distribution and abundance of resources at landscape level, and in this sense caution is required. Secondly, no matter how good some particular habitat is qualitatively, its area in a landscape may still be too low to support a viable population (Andrén 1994, With and Crist 1995, Andrén et al. 1997). Third problem is fundamental. The spatial coverage of managed forests, which are small patterned at stand level, and structurally invariant on larger scales is overwhelming. As a result both the species pool and, especially, the relative abundance of species have changed at community level practically everywhere in managed forest environments. This is followed by changes in species interactions, and the indirect ecological effects of present forest landscape structure manifest themselves in altered significance of these interactions in newly structured communities (Angelstam 1992, Dunning et al. 1992, Wiens et al. 1993, Andrén 1995, Hanski 1995, Kurki 1997). Since this acute and thorough structural change of forest landscapes is relatively rapid in relation to evolutionary time, individuals experience a novel situation and may not be able to properly respond to altered distribution, abundance or behavior of other species.

2 Towards a Comprehensive Yet Rational Solution

Biological diversity needs to be objectified in forest management context. Then, the only way to reasonably define maintenance of biological diversity is to identify it with maintenance of viable populations of all those species that are known or assumed to be members of a natural community in a particular spatio-temporal locality. Theoretically, if all local populations remained viable through time, then, as a result both species diversity and presumably also genetic diversity would be preserved. The third category of biological diversity, that of ecosystems, is a requirement for as well as a result of this viability of local populations. The aforementioned legislative and other control mechanisms also define, either directly or indirectly, an extensive ecological goal that is consistent with the definition above. Their purpose is to maintain, conserve and appropriately increase 'natural' or 'original' biodiversity. From the operational point of view, however, the categorization of biological diversity in these mechanisms is not comprehensive, and therefore the methods of implementation are skewed in relation to different components of diversity. Referring to the problems discussed in sections above, they target either on species whose requirements are able to be fulfilled on relatively small spatial scales or on species whose demand for the abundance of a particular substrate or resource is only moderate.

Because forest management context is bound up with cost-effectiveness, it seems to desire such 'rule-of-thumb' instructions that are thought to indicate or enhance the state of biological diversity and which can be adopted into the present system without any substantial modifications. To some extent the use of these 'rules-of-thumb' is insurmountable, partly because of the stochasticity in nature, but also because applicable ecological knowledge is either incomplete or lacking. As a result forest planning objectives will always be more simplistic than affected biological systems and, thus, ecologically improved forestry practices will be based more or less on averages. It is inevitable, however, that every attempt are made to narrow the gap between variation in nature and uniformity in management practices. Future planning systems must be more amenable to case by case information and this requires naturally a close cooperation between biological and forest sciences. 'Sophisticated rules-of-thumb' must be formulated because, fundamentally, this is a question of 'biodiversifying' forest management rather than managing forest biodiversity.

Due to the fact that there is not any natural state to refer to, except the 'state' of continuous change, the integration of biodiversity conservation with forest management ultimately rests upon subjective choice. First, we must assume what kind of local or regional species assemblage we should maintain. Then we must balance our needs and decide what exactly we are able to maintain by adjusting our forest management procedures, while simultaneously ensuring both the economic viability and social acceptability of our practices. Since the control mechanisms have already defined, in ecological sense, a comprehensive goal for maintenance of forest biodiversity, the main question in this whole issue is then how to create a country-wide approach that is also operationally comprehensive, still being concurrently compatible with socio-economic demands.

2.1 ESC-Strategy: Compromising Comprehensiveness

For implementing international conventions countries are committed to preserve their share of biological diversity. At country level, however, rational and feasible solution approaches can take into account all components only by integrating conservation goals of neighboring spatial units at multiple scales. The aim of this integration is based on the fact that, it is simply impossible to restore and preserve 'original' diversity in every place. By accounting all known elements of biological diversity and integrating conservation objectives it is possible to precisely allocate conservation responsibilities for each area. In other words, the ultimate objective is that all components of original diversity are found somewhere and their viability is ensured on appropriate spatial scales in foreseeable future.

As a premise for this strategy, we need an appropriate spatial baseline, which is, due to the aforementioned need of integrated conservation objectives, applicable also in other spatial scales, both upwards and downwards. Thus, it seems worthwhile to divide country-level and apply biogeographic zones (see Ahti et al. 1968 and Hämet-Ahti 1981 for boreal sub-zoning) within country as ultimate spatial units of population occurrence. Besides that each community should continuously include as many of the original species as possible, this also means that, for achieving the ultimate objective defined above, every species typical to a particular biogeographic zone must have adequate number of viable populations within its borders. The hierarchic spatial division of forest management can be used for actual integration of conservation goals. Lower level spatial units comprise both forest planning areas and protected nature conservation areas. Intermediate level consists of administrative areas of forestry where conservation goals of lower level's units are able to be integrated. Biogeographic zone forms then the higher spatial level where, again, conservation responsibility and objectives of administrative areas are integrated.

Forest species are categorized as 'E', 'S' and 'C' according to the desired occurrence of their local populations. E-species are those, whose minimum resource requirements are able to be fulfilled by means of present stand level management practices, and which can have viable populations in practically all suitable managed forest habitats within their known geographical range (E stands for 'Everywhere'). Usually they are either habitat generalists or such specialists, whose specific requirements happen to correspond with managed forest environment. S-species, in turn, may require more extreme values of habitat variables comparing to what will be commonly found in commercially managed forests (i.e. their quantitative requirements are not fulfilled), or, they may be tightly specialized in some particular resource or habitat characteristic that is either very rare or currently absent (i.e. their qualitative requirements are not fulfilled). These kind of extreme values connect with the need to avoid uniformity following from generalized management instructions. Regardless how regular rules managers desire, all instructions should enable the possibility to increase variance in spatial occurrence of both within-stand habitat variables and also variables that are connected to landscape structure. Furthermore, the spatio-temporal continuity of the occurrence of those extreme values has to be ensured in terms of species ability to disperse in space and in time. S-species need forest management methods divergent from the present ones and are able to occur only on some proportion of their original habitats or in some part of their previous geographical range (S stands for 'Somewhere'). The third category 'C' consists of species that cannot thrive in any managed forests, but are only able to have viable populations almost exclusively in conservation areas. C-species may require, for example, extremely long forest continuity, which is only attainable in strictly protected forests.

The strategy is outlined in Fig. 1. E-species can deal with present forest management and they are able to occur in suitable habitats throughout all forest planning areas. Due to commercial demands, former changes in land use, or other human needs, minimum requirements of all species cannot be fulfilled extensively by adopted management methods; part of the species are excluded from 'average forest' and pushed to the categories S and C. For accomplishing the comprehensive legislative demand concerning conservation of forest biodiversity, emphasis has to be put particularly on systematic maintenance of S-species in managed forests. Initially, there is an urgent need to identify such species or species' groups whose minimum habitat requirements are either quantitatively or qualitatively too wide-ranging comparing to environmental conditions that recently adopted improvements in stand level forestry practices will produce. For many of those species the mentioned extreme values in resource distribution and occurrence are able to be incorporated in forests by increasing the variance in within-stand structure, but for some other S-species the planning and

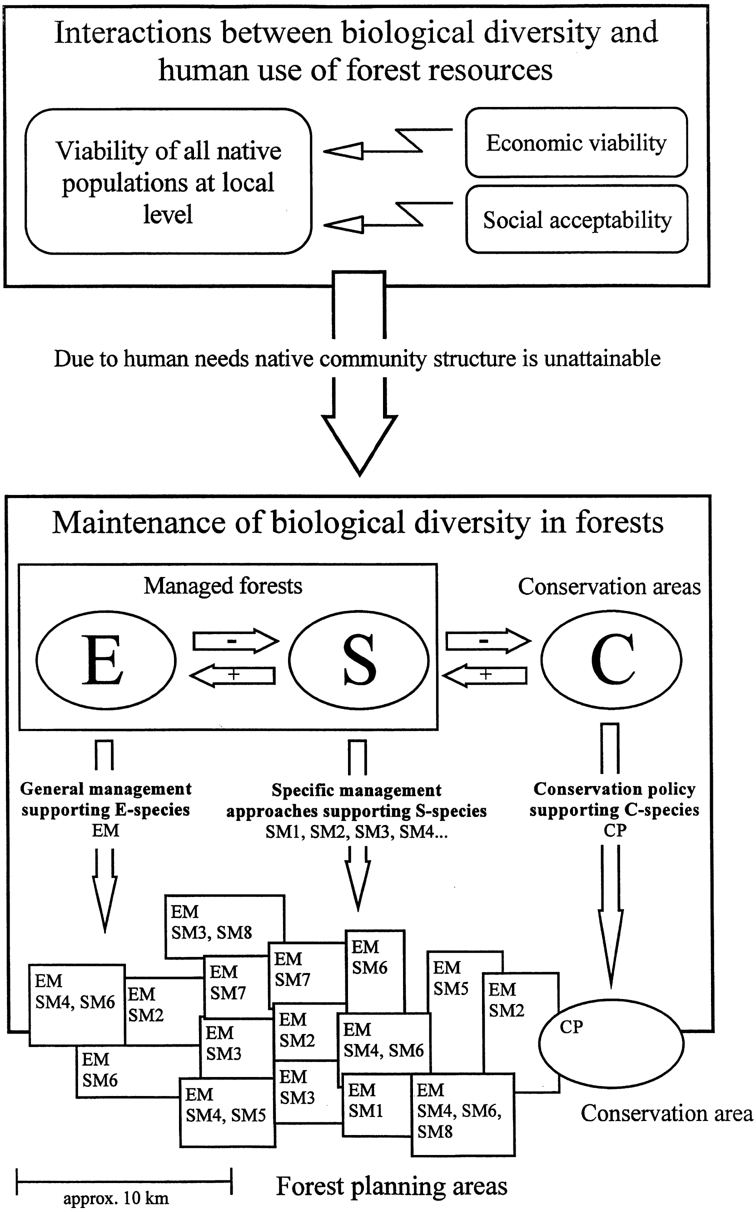

Fig. 1. Due to social and economic aspects of sustainability it is impossible to attain viability of all native populations at local level in managed forests. Forest biodiversity maintenance requires an ESC-strategy, where species are divided according to the best achievable occurrence of their populations in forest landscape. E-species occur 'everywhere' (in all suitable habitats) and are able to deal with general stand-level management practises. S-species occur 'somewhere' (in some part of their original habitats) and require specific, larger-scale management methodology at level of forest planning areas. C-species are only able to thrive in nature conservation areas. Arrows with + and – denote desired and undesired changes in cathegorization of any particular population, respectively.

proper arrangements must acknowledge spatial scales from several adjacent stands to entire forest landscapes. Thus, as distinct from present ecologically based stand level instructions for foresters, it is inevitable that the scale of forest planning areas (see measure in Fig. 1) is in some cases defined as lowest spatial level for biodiversity maintenance in managed forests. Furthermore, scales above stand level hold even more relevance when we are dealing with indirect ecological effects of forest landscape change mentioned in section 1.3.

All forest planning areas have relevant intrinsic characteristics, both regional and local, which define the ecological potential and socio-economic constraints of the area and which must be taken into account when determining area-specific objectives for landscape ecological planning (Fig. 2). Typical characteristics that affect the occurrence of species at present and in future are, for example, the presence and proportion of different forest types, forest structure within stands and at landscape level, key-biotopes and threatened species' habitats, former land-use, present structure of land tenure, and goal setting preferences of land owners. This site-specific information will direct landscape level forest planning, and ecological objectives will considerably vary between planning areas. Besides that the objectives should base mostly on resource requirements of individuals or populations, it is ecologically justified that they also involve attempts to attain a 'more natural' community structure. This means that we should point out such anthropogenic peculiarities in community structure that are of forestry-origin and possibly detrimental to some particular species or group of species. For example, negative population trends of ground nesting forest birds in Fennoscandian managed forests are presumably related to abnormally high densities of middle sized mammalian generalist predator species, both introduced and original (Andrén 1989, Helle and Kauhala 1991, Kurki et al. 1997). Another example is the negative effect of dense populations of large mammalian herbivores on forest vegetation and invertebrate fauna (Edenius et al. 1995, Suominen et al., in press). In both cases relevant mammal species have benefited from the present structure of managed forest landscapes.

Originally, for each planning area, there is a set of potential S-species. In other words, one can compile a list of all those species that are assumed to be natural inhabitants in a certain area, and which can have viable populations in a managed forest environment, but whose habitat requirements can only be fulfilled by specific forest management in suitable places. Then the ecological potential and the socio-economic constraints in a planning area filter away the species whose requirements are beyond all feasible planning objectives regarding forest structure there (Fig. 2). From one planning area to another these potentials and constraints 'select' a suitable subset of S-species thus allocating the conservation responsibilities. Thereafter, proper integration of conservation goals at the levels of administrative areas and biogeographic sub-zones advances the maintenance of forest biodiversity towards operational comprehensiveness at country level.

Species can fall into different ESC-categories in different biogeographic zones. A particular forest species that is able to occur only 'somewhere' in southern Finland may be an E-species in the north and vice versa. After the zonal categorization of species, groups or quilds, we must shift to 'habitat characteristics approach'. To be operable and in concordance with the information needs of forest planners, the habitat concepts, particularly those of S-species, have to be partitioned into measurable environmental variables. These variables and knowledge of species responses to habitat changes can then be used in the definition of area-specific planning objectives that are able to be achieved by specific management practices.

3 Problematic Naturalness of Nature Conservation

Hansson and Larsson (1997) introduced questions concerning species approaches against ecosystem approaches as a new paradigm in conservation research. It is quite reasonable to question whether it is really possible to maintain all species as 'separate units'. Consequently, various ecosystem management models have been customarily applied during recent years. This

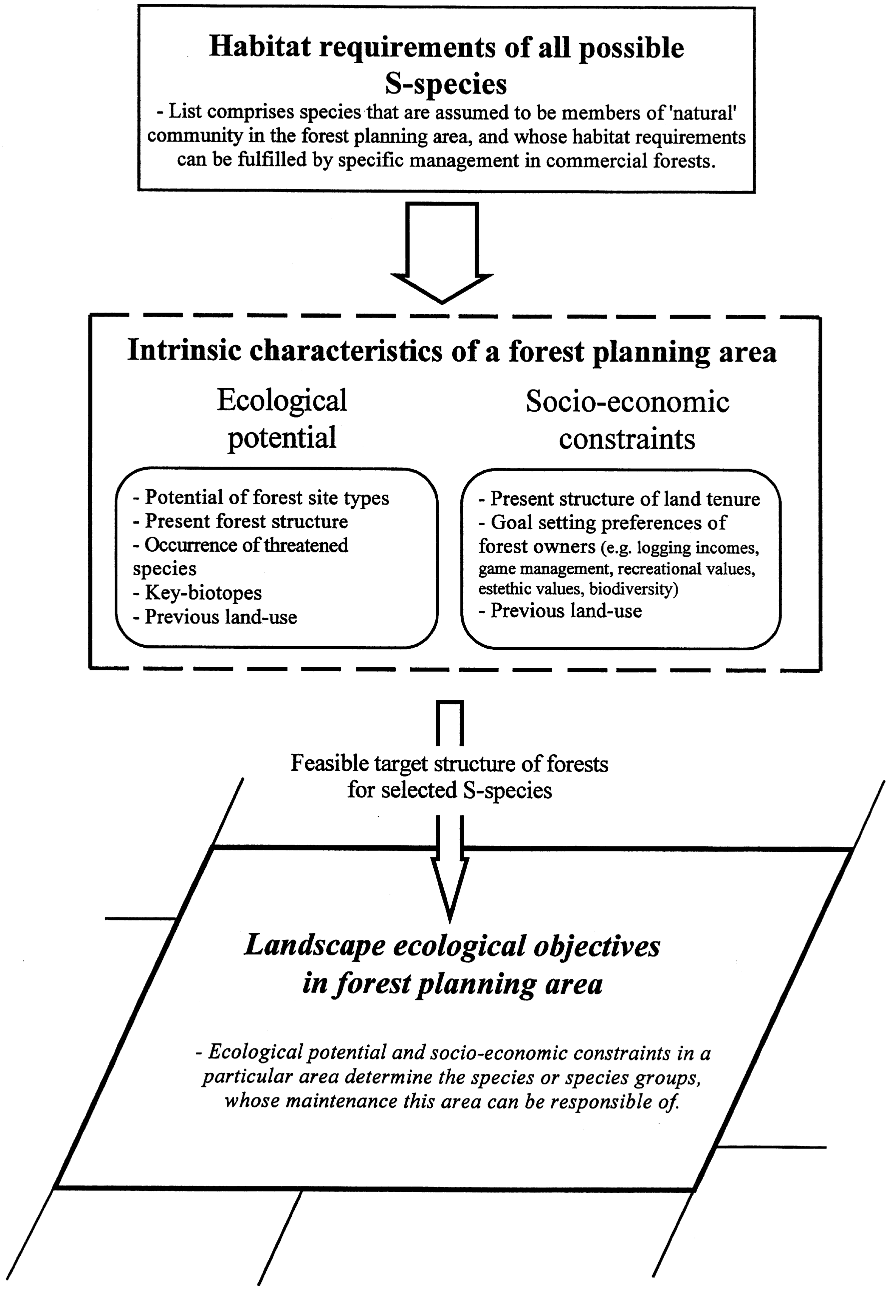

Fig. 2. This is a more precise presentation of the middle vertical arrow in the lower box of Fig. 1, and it explains the formation of landscape ecological objectives in forest planning area. The integration of biodiversity conservation with forest management is based on assumptions of natural assemblages of species, and feasible area-specific objectives ultimately rest upon subjective choice. Each planning area has a set of possible 'somewhere-species', and certain ecological potential and different socio-economic constraints. From area to area these intrinsic characteristics can be considered as a filter that exclude all unfeasible objectives and help to determine the most practicable ones.

presented ESC-strategy may, at first glance, look like mere conservation of single items (species, local populations, actual habitats etc.) over ecosystem processes, and this is also hard to deny, because we have objectified biological diversity in forest management context by identifying it with viable populations of native species. The issue seems, however, a bit more complicated, because the dualism of species and processes in nature is somewhat fake. 'Processes will not proceed' without species, which do not exist without processes, and if we manage either of these we affect the other. Furthermore, in an artifactitious environment like managed forests of Finland, a site-specific maintenance of biological diversity, by concurrently acknowledging socio-economic constraints, is presumably more cost-effective via conservation of 'single items' than natural processes in general. In all, this kind of species-centered approach is possible only because the relatively low number of our forest-dwelling species and the good knowledge of threatened ones enables an adequate follow-up. However, a majority of the processes can perfectly well be defined as planning objectives if the scale and intensity of their natural occurrence matches with socio-economic constraints in managed forests. By and large, extensive and uncontrolled wildfires may be the only natural component of boreal forest that must be excluded from managed forests without exception.

By introducing this strategic approach we want to create a logical backbone for reasonable attempts to diminish the interference between forest biodiversity maintenance and forestry in the future. Because of the logic structure of this strategy, it should be fairly simple for each of us to both apply previously conducted research and to place our present works to the scheme, be they economic, ecological or about social aspects of the issue. From the ecology alone, there is already a vast amount of applicable research results that could be translated to help in development of reasonable area-specific landscape ecological objectives for particular forest planning areas. As regards the relevance of adopted objectives, it is inevitable that they are further defined as ecological knowledge congregates, and that their efficiency and feasibility is repeatedly evaluated by multidiciplinary research. However, if there is a substantial lack of research based knowledge, one must also employ both ecological and planning-related expertise qualified for reasonable and effective goal setting. Certain optimization methods and hierarchic decision processes have already been used for integration of biological expertise into forest planning and decision making (Kangas and Kuusipalo 1993, Kangas and Pukkala 1996). In these studies biodiversity was operationalized by decomposing it into measurable environmental components and the importance of these components was then assessed by pairwise comparisons, and maximization of biodiversity was used as a decision objective. Irrespective of the fact that this kind of maximization is not as such a rational decision objective at a planning unit level, these methods are useful if there is a relatively high level of uncertainty.

In conclusion, it is obvious that small patterned private ownership of forests can be a major restrictive factor in trials of increasing the landscape level heterogeneity in resource occurrence. It is inevitable, even for the slightest progress, that social acceptability is attained by creating fair plans that treat all landowners equally. Furthermore, it is clear that possible spatial arrangements resulting from ecologically justified landscape level planning do not fit into every forest area. Particularly in areas where land use change (usually by agriculture) is considerable, the only rational possibility may be to continue with relatively small variation in the grain-size of environmental heterogeneity. If we intend to keep our conservation methodology socially acceptable as well as our forestry or other resource management systems economically viable, we necessarily have to make ecological concessions at local level. However, we should always be aware and judge the consequences of the concessions made. The strategic ESC-approach may be useful both in reassessing the value of previously achieved applicable research results and in defining the most urgent research needs concerning relationships between environmental conditions and specific requirements of species or species group.

Acknowledgments

This study was financially supported by Kone Foundation and Academy of Finland. We want to express our thanks to Yrjö Haila, Erkki Haukioja, Annika Kangas, Jyrki Kangas, Timo Pukkala, Jukka Salo and Janne Uuttera. They all provided valuable comments on earlier versions of this paper. The English of the paper was revised by Dave Currie and Marja Vieno, whose help is also gratefully acknowledged.

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