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PD2.3.4: Approaches to Modelling Impacts of Forest Management Alternatives on Recreational Use of Forests in Europe

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ABSTRACT

EFORWOOD seeks to develop models for sustainability impact assessments of the European forestry wood chain. This report discusses how and to what extent recreational values can be incorporated into the models. Classic approaches to the modelling of scenic beauty of forests are discussed using public preferences for, and silvicultural characteristics of, individual stands. It is argued that such approaches would be difficult to apply at a European level given the precision required to derive credible results.

Instead a recreational assessment framework is proposed based upon the typology of Forest Management Alternatives and phases of development employed by EFORWOOD WP2.1 which together produce a matrix of 20 forest stand types. It is proposed that recreational scores are derived by WP2.3 during the final year of the project for each forest stand type through expert consultation using a Delphi process. The forest growth simulators used by EFORWOOD for Europe (EFISCEN), and for each of the three case study areas, can then be used to forecast changes in area for each forest stand type in a given region and hence changes in total recreational value of the forests in that region.

To illustrate the approach proposed here, indicative recreational scores have been provided for conifer stands in UK, and projections for the area of each forest stand type have been derived using EFISCEN under a baseline scenario, and a Natura 2000 policy scenario. The results suggest that the total recreational value for conifers in UK would increase significantly under the Natura 2000 scenario when compared with the baseline scenario.

The discussion highlights ways in which the assessment framework could be refined in the future to include additional factors including those relating to spatial location. Conclusions and next steps are outlined, including the need to explore the possibility of using this framework to forecast impacts on recreational value in the three EFORWOOD case study regions, and to forecast impacts on other EFORWOOD indicators such as employment, biodiversity, and risk so that a common approach is followed within Module 2.

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CONTENTS

1. INTRODUCTION

This paper discusses the extent to which assessments of recreational value of forests can be accommodated within the ToSIA tool and other models being developed by EFORWOOD. Two approaches to modelling impacts of forest management on recreational value are presented. The first requires development of regression models that estimate recreational value on the basis of national inventory data for a given region. The second is a simpler assessment framework, arguably with greater potential to be applied across different forest types in Europe. This employs a matrix of 20 forest stand types that are comparable in their silvicultural characteristics across Europe, and assesses impacts on recreational value on the basis of changes to the total area of each stand type in a given region.

The ToSIA tool covers processes in the forestry-wood chain from forest resource management, forest-to-industry interactions, industrial processing and manufacturing, to industry-to-consumer interactions. There are various actual or possible chains that run through these four stages, as defined by different processes such as planting, thinning, harvesting, transport to roadside, primary processing, and so on. A number of scenarios have been selected to develop ToSIA and demonstrate it to potential end-users, including implementation of the Natura 2000 policy to expand the network of protected areas in Europe, and implementation of policies to promote bioenergy. ToSIA will assess their sustainability impacts by forecasting changes to the values of the 24 EFORWOOD indicators. The model is being developed in three regional test cases: Västerbotten in northern Sweden, Baden-Württemberg in southern Germany, and the Iberian Peninsula. The approach will then be extended to the European level with a view to covering between 60 and 80 percent of the wood flow in Europe.

Within Module 2, a typology of silvicultural regimes has been developed that could be generalised across the major European forest types comprising five Forest Management Alternatives (FMAs): 1) forest nature reserve, 2) close-to-nature forestry, 3) combined objective forestry, 4) intensive even-aged forestry, and 5) wood biomass production. The FMAs represent a continuum from intensive production to non-intervention forest management. Each is broken down into four processes, or ‘phases of development’: establishment, young, medium, and adult (Duncker *et al*., 2007). Thus, the five FMAs and four phases give a total of 20 possible forest ‘stand types’. These are shown in Table 1, which summarises the silvicultural treatments that could define each stand type for spruce in the UK.

In outline, the sustainability impact of a given scenario may be assessed as follows. The scenario is expressed as a storyline that specifies changes to key drivers such as oil prices, demographic change, GDP, and rate of technological development. These are inputs to the global forest sector model EFI-GTM, which can be used to forecast production, consumption, import and export quantities and prices for wood products in Europe between the base year of 2005 and the future reference year of 2025 (Kallio *et al*., 2004). The outputs of EFI-GTM are then used by EFISCEN, a forest resource projection model, which can forecast changes to national inventory data, and hence areas of forests that are managed under each stand type (Schelhaas *et al.*, 2007; Nabuurs *et al*., 2007). The forecasts from EFISCEN are also used by subsequent parts of ToSIA to assess levels of activity in the downstream processes throughout the rest of the chain. By deriving current indicator values (i.e. for 2005) per hectare of each stand type, future indicator values (i.e. in 2025) can be calculated by multiplying by the changes in area of each stand type under a given scenario (such as full implementation of Natura 2000). Use of EFISCEN to predict indicator values in this way can then be tested and refined at regional level with regional forest simulators, in particular HEUREKA for Vasterbotten in Sweden and sIMfLOR for Portugal.

Table 1. Descriptions of Forest Management Alternatives for spruce in UK

Forest Management Alternative	Phase of development	Years	Thinning / harvesting years (average)
1. Forest nature reserve	Establishment	0-5	-
	Young	5-15	-
	Medium	15-50	-
	Adult	>50	-
2. Close-to-nature forests	Establishment	0-5	-
	Young	5-15	-
	Medium	15-50	Thinning at years 20, 30, 40, 50, 60
	Adult	>50	Partial felling at years 70-100
3. Combined objective forestry	Establishment	0-5	-
	Young	5-15	-
	Medium	15-50	Thinning at years 20, 30, 40
	Adult	>50	Felling at year 50
4. Intensive even-aged forestry	Establishment	0-5	-
	Young	5-15	-
	Medium	15-50	Thinning at years 25, 35*
	Adult	>50	Felling at year 50*
5. Wood biomass production	Establishment	0-5	-
	Young	5-15	-
	Medium	15-50	Pre-commercial thinning at year 20
	Adult	>50	Felling at year 40

*FMA4 in areas with high wind risk is not thinned and is felled at year 40. See Duncker *et al*. (2007).

2. ASSESSING IMPACTS ON RECREATIONAL VALUE

Recreational benefits derived through direct use of forests are usually assessed through estimates of the number of visits, or visitors, to forests in a given country or region over a given time period (typically 12 months). This can be seen as a proxy for the recreational value of forests (although a more complete measure would also include the quality of the visit experience for different types of recreational user) and has been incorporated into EFORWOOD Indicator #16, 'Provision of Public Forest Services'. The task of linking changes in forest management (caused by a given scenario) to changes in number of visits to forests in a given region is an ambitious one, even in a small case study area. Given the scope of the project, a more modest goal is to link changes in forest management to a relative recreational score for the forests in a given European region. Two approaches to achieving this are presented below.

1. Regression models of recreational value based upon inventory data

The most established approach to modelling recreational values of a forest is to develop regression models which fit recreational scores (or more precisely visual quality scores) with silvicultural variables derived from inventory data. This work was developed in the USA in the 1970s and 1980s using established psychophysical techniques and referred to as the Scenic Beauty Estimation (SBE) method. It sought to predict the SBE for the forests in a given region on the basis of its silvicultural attributes. Brown and Daniel (1984) describe its history, methods and application with reference to pioneering studies by Shafer *et al.* (1969), Daniel and Boster (1976) and Arthur (1977). They summarise their approach as a "method of measuring scenic beauty, standard forest inventory techniques for measuring landscape characteristics, and statistical models to relate the two" (Brown and Daniel, 1984: 3).

Typically, the SBE method involves systematic photography of randomly located views within forested areas. The photographs are then presented to a sample of observers who individually rate the scenic beauty of the image on a ten point scale. The ratings are then adjusted to allow for differences in how individuals used the rating scale to derive unbiased scores for public perception of scenic beauty. The silvicultural attributes of each photographed scene are then measured using standard inventory methods, including ground vegetation, tree height, number of stems, and basal area. A number of regression models are then developed by selecting the optimum number of variables (for which data were available to forest managers) with the most impact on the SBE score. The coefficient for each independent variable in the model reflects its contribution to the overall SBE. Brown and Daniel were able to explain a large proportion of the variance in perceived scenic beauty for the relatively simple ponderosa pine (*Pinus ponderosa*) ecosystem in Arizona where they worked (ibid: 3-9, 28).

Since this study was conducted, the method has been applied extensively, in particular in Scandinavia, possibly aided by the relatively simple structure of the Scandinavian forest landscape. A variation on the method, which has been applied successfully in Catalonia (Blasco *et al.*, 2008), is to take photographs of the target tree species and develop computer images of individual trees, which can then be assembled into images representing near views of forest stands with known combinations of variables such as height, density, and level of ground cover. In principle, a similar approach could be applied within EFORWOOD for the tree species selected for inclusion within ToSIA. The resulting models could then be incorporated into forest growth simulators to determine changes in recreational value under different scenarios. However, the prospects for employing the method across Europe are limited greatly by the resources that would be required.

<u>Use of secondary sources</u>
One alternative that is less resource intensive is to develop the models by inferring the relative preferences for different attributes from information in existing published studies. There is a substantial body of literature on public perceptions of the aesthetic value of different silvicultural attributes, primarily at stand level, in particular tree species composition, tree age, density, ground

cover, type of harvesting regime, and method of regeneration. Key review articles include those by Gundersen and Frivold (2005), Ribe (1989) and Zube *et al*. (1982). In addition to Brown and Daniel (1984), there are also studies which have developed regression models to predict recreational attractiveness on the basis of inventory characteristics (e.g. Silvennoinen, *et al*., 2001; Eriksson and Lindhagen, 2001). This literature is currently being critically reviewed by WP2.3 to explore the extent to which robust conclusions can be drawn regarding public preferences for each attribute, i.e. whether it has a positive or negative impact on recreational value, and the relative impact of each attribute (Marzano *et al*., forthcoming). Provisional conclusions from the review suggest for example that increasing tree age has a highly significant positive impact on recreational value across Europe, while presence of thinning residue beneath the canopy has a small negative impact. The weightings assigned to each attribute could be derived by assessing the number of published references that supported or rejected a particular relationship. Part of the review process involves validating and refining such conclusions through a Delphi process with experts.

The results for each silvicultural variable could in principle be used to derive regression models for the main species included in the project. In conjunction with existing forest simulators, which uses data from national forest inventories, the total recreational value for a region could be calculated, both now and in the future. In outline, this is the approach used by Eriksson and Lindhagen (2001), who developed three regression models for different types of forest with ‘recreational value’, a relative score between 0 and 1, as the dependent variable, and with a range of independent variables relating to stand characteristics using secondary sources from Denmark and Sweden (Jensen and Koch, 1997; Lindhagen and Hörnsten, 2000).

However there are questions surrounding the methodological rigour of the use of secondary sources. Due to the multiplicity of factors that influence recreational value, and the complexity of relationships between them, it may not be possible to transfer a given set of models that work in a particular region to another part of Europe, or another species, with sufficient accuracy. This also applies to models developed from primary research. Likewise, Brown and Daniel concluded that: “A general model, complete with coefficients, for all southwestern ponderosa pine probably would be inadequate for most areas” (Brown and Daniel, 1984: 28).

2. An assessment framework based upon forest management alternatives

Given the resources that would be required to derive valid regression models to cover the whole of Europe through primary research, and the methodological weaknesses of reliance on secondary sources to derive similar models, an alternative is proposed here based on a framework that makes use of the typology of five FMAs and four phases of development as a means to break down the variation in silviculture in a geographical region into a recognised and manageable matrix of 20 forest stand types. A recreational score comparable to the SBE is derived either through expert judgment using a Delphi survey or psychophysical methods similar to those employed for SBEs. A total score for all forests in a given region can be obtained by multiplying the scores for each stand type by its current area in the region. To assess how the total score may change in response to a given scenario, the approach does not require regression models incorporated into forest simulators as described above. Instead, the simulator is used simply to project how the total area of each of the 20 stand types is expected to change between the base year and the reference year under a given scenario. These projected area data are then used to recalculate the total recreational score for the reference year.

To illustrate the approach, indicative scores were derived for conifers in UK through consultation with research colleagues (Table 2), and then the changes in total recreational value were worked through for the Natura 2000 policy scenario using the EFISCEN model. Development of the coniferous forests in the UK was projected up to 2025 under two scenarios with different assumed levels of implementation of Natura 2000. EFISCEN projects the development of the forest resource under a certain demand for wood removals, combined with assumptions on forest management, changes in forest area and possibly changes in increment level due to environmental changes. The calculation used the EFISCEN initialisation data for the UK for coniferous species in 1995 (Schelhaas *et al*., 2006).[1] Wood demand for the period 1995-2005 was derived from FAO statistics (FAOSTAT Forestry data, http://faostat.fao.org/faostat/). Wood demand for the period 2005-2025 was derived from runs with the EFI-GTM model (Kallio *et al*., 2004) under general assumptions of the A1 IPCC scenario (Nakicenovic and Swart, 2000). Wood demand for conifers was projected to increase from 8.7 million m^3 overbark in 2005 to 13 million m^3 in 2025. Under the baseline scenario, it was assumed that there would be no changes in the current Natura 2000 areas.

According to MCPFE (2007) 10,000 ha of forest is currently classified as belonging to MCPFE classes 1.1 and 1.2. These classes comprise area designated for nature protection, with no or very limited management. These forests were assigned to FMA1 (Table 2). A further 135,000 ha is classified as MCPFE class 1.3, managed for biodiversity purposes. It was assumed that this area is managed according to the guidelines of FMA2, and that the three classes together cover the area designated as Natura 2000, which makes up 5.1% of the total area of forest in UK. The remaining 2.24 million ha available for wood supply was distributed over FMA3, 4 and 5, assuming respective shares of 24.1%, 75.5% and 0.4%. An area of 646,000 ha is classified as MCPFE class 2, and managed primarily for the protection of landscape and specific natural elements (MCPFE 2007: 71). This area was assumed to represent FMA3. The remaining area was allocated to FMA4 with a small proportion allocated to FMA5 on the basis of expert judgement. Under the Natura 2000 scenario, the area under FMA1 and 2 in 2025 was increased iteratively until their projected areas together represented 15% of projected total forest area, in line with the target set by the EU. Under both scenarios, annual afforestation of 69,000 ha was assumed (MCPFE, 2007), distributed over FMA3-5 according to their assumed area share. According to the EFISCEN database, 69% of the forested area in UK is covered by coniferous forests. Therefore, all the abovementioned figures were multiplied by 69% to cover coniferous forests only.

Table 2 suggests that the average recreational value per hectare for conifers in UK is currently 3.5 units, on a relative scale from 1 to 10. The value increases to 3.8 under the baseline scenario in 2025, and to 4.1 with full implementation of Natura 2000. Intuitively the direction and relative scale of change is what might be expected given the higher aesthetic and recreational values associated with the natural-looking forest found in protected areas. It is important to note that part of the increase is simply due to an increase in the total area of forests, as demonstrated by the increase in recreational value under the baseline scenario, since it has been assumed that an increase in any type of forest, even those considered relatively unattractive to visitors, would add something to the total recreational value of forests in a given region. Hence, no forest stand type has been assigned a negative recreational score per hectare in Table 2. Note that these are relative scores, and although an increase in the score over time implies an increase in total number of visits to forests in that region, the relationship is unlikely to be linear (see ‘Discussion’ below).

The most robust way to refine the indicative recreational scores per hectare of each forest stand type given in Table 2 would be to use a method comparable to the SBE approach whereby a representative sample of individuals drawn from the population are asked to score a series of photographs or computer generated images chosen systematically to represent the diversity present within each stand type for a given species in a given region. The average score for all images generated by all participants for a given stand type would provide the overall recreational score for that stand type.

[1] It may have been more accurate to run the model with some demand for FMA1 until 2005 and set it aside after that date, rather than setting it aside in 1995, but this would have required significantly extra work, and it is not certain that it would have been a more realistic assumption than setting it aside in 1995.

Table 2. Impacts on recreational value of conifer forests in UK in 2005, and 2025 under the baseline and Natura 2000 scenarios, using indicative recreational scores

FMA	Phase of development	Age	Rec. score /ha	2005		2025			
						Baseline scenario		Natura 2000 scenario	
				Area (1000 ha)	Rec. score	Area (1000 ha)	Rec. score	Area (1000 ha)	Rec. score
1	Establishment	0-5	5	0.1	0.6	0.0	0.0	0.0	0.0
	Young	5-15	3	0.8	2.5	0.0	0.0	0.0	0.0
	Medium	15-50	7	4.7	32.8	3.1	21.8	9.4	65.5
	Adult	>50	10	1.3	12.8	3.8	37.8	11.3	113.3
	Sub-total			**6.9**	**48.6**	**6.9**	**59.6**	**20.7**	**178.9**
	Average				**7.0**		**8.6**		**8.6**
2	Establishment	0-5	5	3.2	16.2	2.5	12.3	7.6	37.8
	Young	5-15	3	12.6	37.7	3.8	11.4	17.7	53.0
	Medium	15-50	6	63.2	379.3	46.6	279.8	137.5	825.1
	Adult	>50	9	14.1	127.0	40.2	362.1	116.7	1050.3
	Sub-total			**93.2**	**560.3**	**93.2**	**665.7**	**279.4**	**1966.2**
	Average				**6.0**		**7.1**		**7.0**
3	Establishment	0-5	5	39.8	199.2	48.2	241.0	46.7	233.6
	Young	5-15	2	71.3	142.6	75.3	150.7	69.0	138.0
	Medium	15-50	4	252.8	1011.2	257.9	1031.7	232.6	930.5
	Adult	>50	8	29.5	236.2	54.0	431.7	38.9	311.2
	Sub-total			**393.5**	**1589.2**	**435.4**	**1855.1**	**387.2**	**1613.2**
	Average				**4.0**		**4.3**		**4.2**
4	Establishment	0-5	4	124.8	499.2	151.0	604.0	146.4	585.4
	Young	5-15	1	223.4	223.4	236.0	236.0	216.1	216.1
	Medium	15-50	3	791.9	2375.8	808.1	2424.2	728.7	2186.2
	Adult	>50	8	92.5	739.8	169.1	1352.5	121.9	974.9
	Sub-total			**1232.7**	**3838.3**	**1364.1**	**4616.6**	**1213.0**	**3962.6**
	Average				**3.1**		**3.4**		**3.3**
5	Establishment	0-5	3	0.7	2.0	0.8	2.4	0.8	2.3
	Young	5-15	1	1.2	1.2	1.3	1.3	1.1	1.1
	Medium	15-50	2	4.2	8.4	4.3	8.6	3.9	7.7
	Adult	>50	8	0.5	3.9	0.9	7.2	0.6	5.2
	Sub-total			**6.5**	**15.5**	**7.2**	**19.4**	**6.4**	**16.4**
	Average				**2.4**		**2.7**		**2.5**
Total				**1732.7**	**6051.8**	**1906.8**	**7216.4**	**1906.8**	**7737.3**
Average					**3.5**		**3.8**		**4.1**

Such a 'recreational assessment framework' has advantages over the use of regression models. First, it is time-consuming to generate images of randomly selected views from a forest landscape, and to collect inventory data for the trees found within each view. Secondly, the scope for developing regression models is restricted to the limited range of silvicultural variables that are available within national inventory databases to characterise a given forest view. However, the recreational value of the forest view in question is likely to depend significantly on additional silvicultural factors that the national inventory, and/or the forest simulator, may not be able to record or model, including precise characteristics of ground vegetation cover, residue from felling and thinning operations, techniques for ground preparation. These additional characteristics would not be reflected in the recreational scores derived from regression models, but with the assessment framework they would be reflected in the scores per hectare of each stand type.

Applying the Delphi method

Since the recreational assessment framework does not require recreational scores to be characterised by a limited number of silvicultural variables available within national inventory databases, there is also more flexibility in what the stand types can look like. They need not be restricted to stands of single species and ages so that regression models can be fitted easily to their silvicultural characteristics. Instead scores may be derived for ‘all conifers’ as suggested in Table 2, or for mixtures of broadleaved and coniferous species of different ages, as is often the case for stands of FMA1, 2 and 3. Hence, the framework has potentially wider and more flexible application than regression modelling. However, some of the accuracy possible with modelling of more homogenous stands will inevitably be lost, and, more importantly, it may not be possible to use forest simulators to determine the area of stand types with complex silvicultural characteristics, and hence to derive total recreational values for forests in a given region.

One solution would be to use expert judgement, again through a Delphi process, not to derive recreational scores, but to forecast direction and scale of change in the areas of each stand type. The Delphi survey would involve groups of experts, possibly from a number of relevant specialist fields, who work towards consensus regarding the data needs of the framework given in Table 2. Such a process could be supported by available information from forest simulators on likely changes in areas of certain forest types. As with classic applications of the method, the experts would remain anonymous, providing answers to a questionnaire along with explanations for their answers. The information would be summarised by the facilitator and redistributed to participants who would then be invited to revise their original judgments in the light of the full set of anonymous responses. The process would undergo a series of iterations until consensus or stability in the responses is reached. Use of an internet website could aid the process, especially in a pan-European context, as well as ensuring anonymity, although there may be advantages in conducting the discussion in a face-to-face workshop.

Delphi methods are well suited to ex ante impact assessments of land use change, and this application of the method more closely resembles its established use as a forecasting tool than its use to derive recreational scores (Linstone and Turoff, 1975). Recent studies have broadened its application to include valuation of ecosystem goods and services (Curtis, 2004), identification of indicators to assess vegetation condition (Oliver, 2002), and selection of focal species to evaluate potential environmental impacts of land use change (Hess and King, 2002). By employing a Delphi method, the framework would become a rapid assessment tool that is able to indicate direction and scale of impact of scenarios on recreational value and a number of other key sustainability indicators. Its simplicity and transparency would lend itself well to use within multi-stakeholder settings. In certain contexts, the reduction in accuracy of the analysis may be compensated for by the enhanced legitimacy the approach receives through the opportunities it presents for stakeholder engagement. In contrast, for some potential end-users, a complex impact assessment tool such as ToSIA may be seen as a ‘black-box’ whose internal function remains opaque and inexplicable and hence the tool may not trusted or used (Tabbush *et al*., 2008).

3. DISCUSSION

This section discusses theoretical and methodological issues that are raised by the use of the proposed recreational assessment framework. First, to what extent are generalisations possible about public preferences for forest types? Secondly, what is the scope for linking relative recreational values to numbers of visits? These issues are explored in turn below.

1. Generalisations about public preferences

An important question concerns the extent to which generalisations can be made about preferences for forest recreation given that the conclusions drawn from published studies are typically site-specific with little evidence of wider applicability (Ribe, 1989: 70). What is the level of variation in recreational scores for a given stand type across different geographical regions, social groups, and recreational activities? It is worth highlighting here that EFORWOOD is only concerned with preferences for silvicultural characteristics. There are likely to be wide variations in preferences between social groups for non-silvicultural features such as trails, interpretation and facilities, and these are discussed in a later section.

Regional disaggregation

Application of the framework across the whole of Europe would require some degree of spatial disaggregation to reduce the variation in forest types, silvicultural regimes, and patterns of, and preferences for, recreational use of forests within a given geographical unit of analysis. The national level would be most appropriate, allowing national inventory data to be used, although at a later stage further disaggregation may be advantageous in some countries. With up to 20 stand types and perhaps two major tree species selected for each European country, around 1000 separate scores would need to be estimated. It would be prohibitively expensive and probably unnecessary to derive all of these scores from primary research. Instead, a larger spatial scale would need to be employed. A promising option would be to use the five European Forest Recreation Regions (FRRs) identified by Bell *et al*. as the level of analysis. The FRRs are defined in terms of differences in forest cover and type, patterns of recreational use, and potential conflicts over forest use, as follows: Atlantic, Nordic, Central Europe, Continental, and Mediterranean (Bell *et al*., 2007: 26-29). The same recreational score could be used for each country that falls within a given FRR, or refinements could be made to reflect differences between countries on the basis of a Delphi survey. Once scores for each country are obtained, the framework would be applied at national level: estimates for total area of each stand type, for each species (or for 'broadleaves' and 'conifers'), and for each country would be estimated for the base year, and forecasted for the reference year in response to a given scenario, in order to calculate the impact of that scenario on recreational value.

Individual variations

Individuals within different social categories such as age, gender, ethnicity, socio-economic group, level of education, residential location, and profession, may have different perceptions of recreational value of the same forest stand. Jensen and Koch (1998: 43) note that: "preferences of visitors can vary considerably, even over shorter distances, from one cultural area to another and even between different segments of the population". Numerous authors have highlighted differences between social groups on the basis of case study research (e.g. Bradley and Kierney, 2007; Gundersen and Frivold, 2005: 12; Jensen, 1993; Lee, 2001: 71; Nielsen *et al*., 2007: 64; Rametsteiner and Kraxner, 2003). The extent to which many of these conclusions about specific social groups can be generalised at national level is likely to be limited (Marzano *et al*., forthcoming). One possible generalisation that may hold across Europe concerns differences in attitudes of people with different levels of knowledge about forestry practice. Foresters tend to be more accepting of intrusive silvicultural interventions such as clear-felling and thinning operations in the short term before the site has regenerated or recovered (e.g. Bliss 2000: 7). Arguably, at national level the variation in preferences between individuals may be more significant than the variation between these social categories. Instead of disaggregating the analysis for different social groups, the overall variation in preferences could be represented by quoting a range of scores for each stand type, rather than a single figure, derived where possible from robust research with a representative sample of the population in a given country.

Recreational activities

The classic approaches to landscape preference research outlined above are based on individual perceptions of near-view 'scenic beauty', 'aesthetic value, or 'visual quality' of the forest stand depicted in photographs or computer images. To what extent can it be claimed that visual quality scores obtained through this method reflect preferences to visit that site for recreational use? Is it necessary to disaggregate between different types of recreational user such as walkers and hunters? Few published preference studies appear to have differentiated between aesthetic and recreational values to show how preferences differ according to how the forest is used. In one Finnish study, mature, sparsely stocked birch stands were rated highly for beauty but mature pine stands were preferred for recreation (Pukkala *et al*., 1988: 281).

Brown and Daniel suggest that interactions between visitors and the forest environment can be located on a continuum between an emphasis on the recreational activity itself (such as white water kayaking) and emphasis on the aesthetic experience (such as hiking, and driving for pleasure), with activities such as hunting and fishing located somewhere between the two. Furthermore the emphasis may shift from moment to moment for any one individual (Brown and Daniel 1984: 2). An individual's aesthetic preferences may also change over time due to a sense of familiarity and attachment to a site or a type of site that is used habitually for a particular recreational activity. This could be the case for some users of popular mountain biking sites in Scotland within areas of intensive even aged forest generally regarded to be of relatively low aesthetic value. In the face of this variation, Brown and Daniel conclude that: "the scenic beauty of the forest environment probably always makes some contribution to visitor satisfaction, and in many cases is the predominant component" (ibid). In doing so they support their methodology as a means to help mangers reach trade-offs between the competing needs of timber production and recreational use of forest land.

In several regions, the most important forest based recreational activities in terms of visit numbers are probably walking, dog-walking, cycling and jogging. This is the case for urban and peri-urban forests near Vienna (Arnberger, 2006) and for the whole of Scotland (Edwards *et al*., 2008). These four activities can be considered mutually exclusive in that a trip involving one of them is unlikely to involve any of the others. Together they account for 98% of all visits to Scottish forests. It may be hypothesised that they represent the end of Brown and Daniel's continuum where aesthetic values are most important. Hence, for Scotland, scores which measure visual quality may be a close proxy for recreational value. In other countries the list is more diverse, for example a Swedish study indicated high levels of participation in walking, berry picking, cycling, hunting, fishing, bathing and skiing (Hörnsten, 2000: 8). Following Brown and Daniel, it may be necessary to assume that scores for visual quality of a stand act as a proxy for preferences for all major types of recreational use. Later, with robust primary research, informants could be asked to state their preferred recreational activity in forests and to score each view accordingly.

2. The scope for modelling forest visits

The recreational scores indicated in Table 2 are more accurately referred to as 'potential' recreational scores. They reflect public preferences for a given stand type solely on the basis of its silvicultural attributes at stand level regardless of its location in relation to other forest stands and other factors influencing its attractiveness for recreation. In contrast, the most useful definition for the 'actual' recreational value is arguably the total time spent visiting a given area over a given period of time, or more simply the number of visits per hectare per year. Ideally, the quality of the visit experience would also be included, although to some extent this will be reflected in the number of visits. Bridging the gap between 'potential' recreational scores and numbers of visits raises a series of conceptual problems. A useful point of departure is the work of Hill *et al.* who developed a model to predict the number of visits made to a given forest over a given time period for publicly accessible forest sites in

Great Britain (Hill *et al*., 2003; cf. Brainard e*t al*., 2001. The functional structure of the model is as follows:

$Visits_i = f (Att_i, Pop_i, Sub_i, Char_i)$

Where $Visits_i$ refers to the number of visits made to forest *i*, Att_i are variables that reflect the attributes of the site, Pop_i is a measure of the population within a given travel time; Sub_i represents the accessibility of substitute forest sites, and $Char_i$ reflects the socio-economic characteristics of the surrounding population (Hill *et al*., 2003: 4). Prospects for incorporating each of these variables into the framework are discussed below.

Accessibility of the site

The geographical location of a stand can have a major impact on the number of visits it receives. An attractive forest in an inaccessible location may receive few visits compared to an identical forest located near a city simply due to the additional average time and cost that would be required to reach the site. Its contribution to the 'actual' recreational value of all forests in the region may therefore be low. Similarly, private woodlands may receive fewer visits than those in public ownership. In principle, if each forest stand can be located spatially, the total recreational score for a region could be weighted by an accessibility factor using a proxy measure to derive a score that more accurately reflects the proportion of visits that the forest receives. Hill *et al.* concluded that population living in a two hour drive of the site (Pop_i) provided a simple and robust measure. This was refined by including certain socio-economic characteristics of that population ($Char_i$). A similar approach has been applied to a forest simulator in Sweden to assess likely impacts of changes to forest management on recreational value of forests, building on Eriksson and Lindhagen (2001). The distance to the nearest road was used as a proxy for accessibility for recreation. Later it may also be possible to use a similar approach with EFISCEN-Space, a spatially-explicit version of EFISCEN which uses a 1 km grid. Hence, a refinement to the assessment framework along these lines may therefore be possible.

Silvicultural attributes at landscape level

Regarding the attributes of the site, EFORWOOD is currently restricted in its scope to impacts of changes in silvicultural attributes at stand level. However, other types of site variables can have a substantial impact on visit numbers as follows: a) silvicultural attributes at the forest or landscape level, b) physical features such as viewpoints, rivers and lakes, and cultural heritage sites, and c) recreational infrastructure and services.

Regarding silvicultural attributes at forest, or landscape, level, the most promising variable, which could potentially be modelled, is the diversity between stands. Generally, public perceptions of recreational value appear to increase with the level of silvicultural diversity in the forest, particularly with respect to tree species and age (cf. Axelsson-Lindgren and Sorte, 1987). Such diversity can be conceptualised in different ways. As visitors pass through a forested landscape they may experience a shift between: a) different FMAs (e.g. between close-to-nature broadleaved stands and productive coniferous stands); b) different phases of development for the same FMA (e.g. young and old stands of intensive even aged forestry), or c) different types of land use (e.g. forest and agriculture). Each may be valued differently, perhaps more highly, than a walk through a uniform land use type.

The diversity within a forest stand is to some extent already included within the definitions of each FMA, but diversity between stands is harder to incorporate into the framework. It would be necessary to know the spatial distribution of each FMA, and to forecast how the distribution would evolve over time in response to a given scenario. Assuming this were possible, the extent to which adjacent stand types differ from each other could be quantified with a suitable diversity index, and used to weight the total recreational scores for all of the forests in a given region under each scenario. Such a refinement may only be possible in a case study where each stand can be located on a GIS.

Alternatively, the density of forest management units (FMUs) could act as a proxy for diversity between stands (assuming that the majority of contiguous FMUs are managed differently from each other, which is not always the case). The assumption here is that the negative effects of any intervention may be reduced when they are carried out on a smaller scale. For example, large clear-fell areas are generally regarded as visually undesirable. A contrasting view may be expressed within forest landscape design guidelines which assert that small forest coupes may appear out of scale when viewed from a distance within a panoramic view (Forestry Commission, 1994: 6). In the aggregate, it could be hypothesized that the density of FMUs correlates with spatial diversity, and hence with higher recreational value, and used to weight the total recreational scores for the forests in a given region under each scenario.

Non-silvicultural attributes

Incorporating non-silvicultural factors such as recreational infrastructure and services into the framework also presents challenges. In theory, one way to capture the additional recreational value they provide would be to weight the total scores for the forests in a given region under a given scenario according to the level of financial investment in recreation. In practice, the framework may not be able to include such investments with sufficient accuracy except at case study level.

At the forest level, visit flows are often manipulated by the forest manager to encourage use of particular zones through the location of entry points, car parks, facilities, signs and other forms of interpretation. This may be done to optimise the recreational value of attractive sites set aside for recreational use (such as mature stands of FMA2 and 3), or to minimise conflicts with competing alternative uses of the forest (such as areas with forest operations or areas of FMA1 sensitive to visitor pressure). In some forests, for example where FMA2 stands are already physically separated from stands of FMA4 and 5, the impact this has on the exposure of different stand types to visitors may be considerable, given the suggestion that many forest visitors will only use the area within 100-200 m of a car park (Bateman, 1996).

This effect represents a conceptual limitation to the assessment framework. Visitor flows are manipulated to favour more attractive stands largely on the basis of the managers' perceptions of their potential recreational score. As a result, multiplying recreational scores by an accessibility factor that reflects managers' perceptions of those scores could lead to double-counting or at least a significant distortion of the actual recreational value. The problem could be resolved with a spatially explicit case study by adopting a different approach to the assessment framework described above. The proportion of total visit time spent within each stand type could be measured empirically (for example through use of GPS equipment combined with on-site surveys) and used as a direct measure of recreational value of that stand type, in which case the use of 'potential' recreational scores based upon perceptions of silvicultural attributes would not be necessary. This approach could prove to be a fruitful line of enquiry for future research.

CONCLUSIONS AND NEXT STEPS

There is a need to ensure that SCVs are incorporated better within the impact assessment tools that are being developed by EFORWOOD to assess the impacts of forest management alternatives on the sustainability of the European forestry-wood chain. Otherwise the project may give the false impression that the only significant social values associated with the forestry-wood chain are those relating to employment. This goal may be achieved by seeking to incorporate a measure of recreational value of the silvicultural attributes at forest stand level, which can act as a proxy for the considerable benefits derived by the European population through direct engagement with forests. The recreational assessment framework proposed here can be used to achieve this. It is based upon the use of recreational scores for different forest stand types in Europe, derived through a combination of psychophysical surveys and Delphi surveys. Forest growth simulators are then used to forecast changes in area of each forest stand type, and hence changes in the total recreational value for the forests in a given region. This approach to modelling impacts of EFORWOOD scenarios on recreational values has now been incorporated into EFISCEN at European level for the Natura 2000 policy scenario using the indicative recreational values in Table 2.

The following actions are now proposed for inclusion in the Implementation Plan for WP2.3 for the remainder of the project.

1. Discussion with Module 1 to determine whether to propose that ‘recreational value’ as defined in this report becomes incorporated into EFORWOOD Indicator #16 ‘Provision of Public Forest Services’ and into the short-list of indicators for inclusion in ToSIA.

2. Discussion with other WPs in Module 2 to explore the extent to which this framework can be used for other indicators, such as employment, biodiversity, and risk, so that a common approach is used.

3. Derivation of more accurate recreational scores for different European regions, through a Delphi process, to refine those given in Table 2, and their use within EFISCEN.

4. Exploration of the extent to which the approach can also be incorporated within the three simulators employed by the case study areas: HEUREKA for Vasterbotten, W+ for Baden-Wurttemberg, and sIMfLOR for Portugal.

5. Also, where regional simulators allow forest stands to be located spatially using GIS, exploration of the possibility to incorporate additional factors, in particular the accessibility of each forest stand type using a proxy measure such as population within a certain radius, and possibly silvicultural diversity at landscape level.

6. Later, in an intensively researched case study area, there may be scope for developing the framework so that it can forecast changes to absolute numbers of visits. Although this work would lie beyond the timescale of EFORWOOD, it could be valuable to develop a conceptual framework that describes how this would be done.

REFERENCES

Arnberger, A., 2006. Recreation use of urban forests: an inter-area comparison. Urban Forestry and Urban Greening, 4, 135-144.

Arthur, L.M., 1977. Predicting scenic beauty of forest environments: some empirical tests. Forest Science 23(2), 151-159.

Axelsson-Lindgren, C. and Sorte, G. 1987. Public response to differences between visually distinguishable forest stands in a recreation area. Landscape and Urban Planning, 14, 211-217.

Bateman, I.J., 1996. Comparison of forest recreation, timber and carbon fixing values with agriculture in Wales: a GIS/CBA approach. Ph.D. Thesis, University of Nottingham.

Bell, S., Tyrväinen, L., Sievänen, T., Pröbstl, U. and Simpson, M., 2007. Outdoor recreation and nature tourism: a European perspective. Living Reviews in Landscape Research.

Blasco, E., González, J.R., Rodríguez, P., Pukkala, T., Kolhemainen, O., Palahí, M. Forthcoming 2009. Predicting scenic beauty of forest stands in Catalonia (North-East Spain). Journal of Forestry Research.

Bliss, J.C., 2000. Public perceptions of clearcutting. Journal of Forestry, 98, 4-9.

Bradley, G.A. and Kearney, A.R., 2007. Public and professional responses to the visual effects of timber harvesting: different ways of seeing. Western Journal of Applied Forestry, 22, 42-54.

Brainard, J., Bateman, I. and Lovett, A., 2001. Modelling demand for recreation in English woodlands. Forestry, 74(5), 423-437.

Brown, T.C. and Daniel, T.C., 1984. Modeling forest scenic beauty: concepts and application to ponderosa pine. USDA Forest Service Research Paper RM-256, 38 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Curtis, I.A., 2004. Valuing ecosystem goods and services: a new approach using a surrogate market and the combination of a multiple criteria analysis and a Delphi panel to assign weights to the attributes. Ecological Economics, 50, 163-194.

Daniel, T.C. and Boster, R.S., 1976. Measuring landscape esthetics: the scenic beauty method. USDA Forest Service Research Paper RM-167, 66 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Duncker, P.H., Spiecker, H. and Tojic, K., 2007. Definition of forest management alternatives. EFORWOOD Deliverable D2.1.3. Albert-Ludwigs-Universität, Instiitite for Forest Growth, Frieburg.

Edwards, D.M., Morris, J., O'Brien, L., Sarajevs, V. and Valatin, G., 2008. The economic and social contribution of forestry for people in Scotland. Forestry Commission Scotland Research Note FCRN102, Forestry Commission, Edinburgh.

Eriksson, L. and Lindhagen, A., 2001. A model indicating effects of multi-purpose use of forestry at the stand level. Economic Sustainability of Small-Scale Forestry, EFI Proceedings No. 36. European Forest Institute, Joensuu, Finland.

Forestry Commission, 1994. Forest landscape design guidelines. Forestry Commission, Edinburgh.

Gundersen, V.G. and Frivold, L.H., 2005. Integrating visual structures in urban silviculture: a review of Fennoscandian preference studies and a proposal for a zoning model. Paper 3 in: Urban woodland management in Norway: integrating aesthetic and ecological elements in silviculture. Unpublished PhD Thesis, Norwegian University of Life Sciences.

Hess, G.R. and King, T.J., 2002. Planning open spaces for wildlife I. Selecting focal species using a Delphi survey approach. Landscape and Urban Planning, 58, 25-40.

Hill, G., Courtney, P., Burton, R. and Potts, J., 2003. Forests' role in tourism: Phase 2. Report to Forestry Commission, Edinburgh.

Hornsten, L., 2000. Outdoor recreation in Swedish forests – implications for society and forestry. Department of Forest Management and Products. Uppsala, Swedish University of Agricultural Sciences.

Jensen, F.S., 1993. Landscape managers' and politicians perception of the forest and landscape preferences of the population. Forest and Landscape Research, 1, 79-93.

Jensen, F.S. and Koch, N.E., 1997. Friluftsliv i skovene 1976/77 – 1993/04. Den Kgl. Veterinaer og Landbohøjskole. Forstkningcentret for Skov og Landskab. København, Denmark.

Kallio, AMI, Moiseyev, A. and Solberg, B., 2004. The global forest sector model EFI-GTM: the model structure. EFI Technical Report 15, European Forest Institute, Helsinki, Finland.

Lee, T.R., 2001. Perceptions, attitudes and preferences in forests and woodlands. Forestry Commission Technical Paper 18. Forestry Commission, Edinburgh.

Lindhagen, A. and Hørnsten, L., 2000. Forest recreation in 1977 and 1997 in Sweden – changes in public preferences and behaviour. Forestry, 73(2), 143-153.

Linstone, H.A. and Turoff, M., 1975. (Editors). The Delphi method: techniques and applications. Addison Wesley, Boston, MA, USA.

Marzano, M., Edwards, D.M., Gonzales, J.M., Jay, M., Jensen, F.S., Montagne, C. and Weiss, G., Forthcoming. The impact of forest management on social and cultural values in Europe: public preferences for forest management alternatives. EFORWOOD Deliverable D2.3.3. Forest Research, UK.

MCPFE, 2007. State of Europe’s forests, 2007. Ministerial Conference on the Protection of Forests in Europe, Liaison Unit, Warsaw.

Nabuurs, G.J., Pussinen, A., Brusselen, J, van and Schelhaas, M.J. 2007. Future harvesting pressure on European forests. European Journal of Forest Research, 126(3), 391-400.

Nakicenovic, N. and Swart, R. (Editors), 2000. Special Report on Emission Scenarios. Cambridge University Press, Cambridge, UK.

Nielsen, A.B., Olsen, S.B. and Lundhede, T., 2007. An economic valuation of the recreational benefits associated with nature-based forest management practices. Landscape and Urban Planning, 80, 63-71.

Oliver, I., 2002. An expert panel-based approach to the assessment of vegetation condition within the context of biodiversity conservation Stage 1: the identification of condition indicators. Ecological Indicators, 2(3), 223-237.

Pukkala, T., Kellomäki, S. and Mustonen, E., 1988. Prediction of the amenity of a tree stand. Scandinavian Journal of Forest Research, 3, 533-544.

Raison, R.J., Flinn, D.W. and Brown, A.G., 2001. Application of criteria and indicators to support sustainable forest management: some key issues. Chapter 2 in: Raison, R.J., Brown, A.G., and Flinn, D.W. (Editors), 2001. Criteria and indicators for sustainable forest management. IUFRO Research Series No. 7. CABI Publishing, Wallingford, UK, pp. 5-18.

Rametsteiner, E. and Kraxner, F., 2003. Europeans and their forests: what do Europeans think about forests and sustainable forest management? MCPFE Liaison Unit, Vienna.

Ribe, R.G., 1989. The aesthetics of forestry: what has empirical preference research taught us? Environmental Management, 13, 55-74.

Schelhaas, M.J., Eggers, J., Lindner, M., Nabuurs, G.J., Pussinen, A., Päivinen, R., Schuck, A., Verkerk, P.J., van der Werf, D.C. and Zudin, S., 2007. Model documentation for the European Forest Information Scenario model (EFISCEN 3.1). Wageningen, Alterra, Alterra report 1559, EFI Technical Report 26, Joensuu, Finland. 118 p.

Schelhaas, M.J., Varis, S., Schuck, A. and Nabuurs, G.J., 2006. EFISCEN Inventory Database. European Forest Institute, Joensuu, Finland. http://www.efi.int/portal/virtual_library/databases/efiscen/

Silvennoinen, H., Alho, J., Kolehmainen, O. and Pukkala, T., 2001. Prediction models of landscape preferences at the forest stand level. Landscape and Urban Planning, 56, 11-20.

Shafer, E.L., Jr., Hamilton, J.F., Jr. and Schmidt, E.A., 1969. Natural landscape preferences: a predictive model. Journal of Leisure Research 1(1), 1-19.

Tabbush, P., Frederiksen, P. and Edwards, D.M., 2008. Impact assessment in the European Commission in relation to multifunctional land use. Chapter 2 in: Helming, K., Perez-Soba, M. and Tabbush, P. (Editors), 2008. Sustainability impact assessment of land use changes. Springer Verlag, Berlin and Heidelberg, pp. 35-54.

Zube, E.H., Sell, J.L. and Taylor, J.G., 1982. Landscape perception: research, application and theory. Landscape Planning, 9, 1-33.