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# Modelling the Impacts of Forest Management Alternatives on Recreational Values in Europe

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**ABSTRACT**

This report demonstrates the application of recreational scores, obtained through a pan-European Delphi survey as part of EFORWOOD, to model the impacts of changes in forest management on the recreational value of European forests. Changes in the level of implementation of the Natura 2000 policy is used as an example. Currently, about 8% of the EU forest area is allocated to biodiversity conservation (MCPFE class 1; MCPFE 2007). According to the Natura 2000 Agenda, 15% of the territory of the EU should be designated as conservation area by 2025. It is to be expected, therefore, that the forest conservation area will increase considerably in the near future. The impact of different nature conservation implementation levels on the recreational value of forests in Europe was explored using recreational scores derived from the Delphi survey, and combined with outputs from the forest scenario model EFISCEN. Changes in recreational value were considered against two background futures (A1 and B2 from the SRES scenarios) and three different nature conservation implementation levels. The results suggest that overall an increase in forest area managed for conservation would cause a slight net increase the recreational value per hectare of forests in Europe, although there is considerable variation between countries.

## CONTENTS



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## 1. INTRODUCTION

This report demonstrates the application of recreational scores, obtained through a pan-European Delphi survey as part of EFORWOOD, to model the impacts of changes in forest management on the recreational value of European forests. Changes in the level of implementation of the Natura 2000 policy is used as an example.

On average about 8% of the European forests (excluding the Russian Federation) are currently protected with the main objective of biodiversity conservation (MCPFE 2007). This ranges from 0.5% in Portugal to 33.9% in Luxembourg (Figure 1). At the European level about half of the protected forest area is classified as having no or minimal management (MCPFE classes 1.1 and 1.2, respectively), whereas the other half is managed actively for biodiversity conservation (MCPFE class 1.3). The approach to forest biodiversity conservation differs considerably among countries. Some countries, e.g. Portugal, Ireland and Norway, classify all their total protected forest area as area with no or minimal management, whereas other countries, e.g. UK, Germany and Luxembourg, classify most of their protected forest area as actively managed for biodiversity conservation.

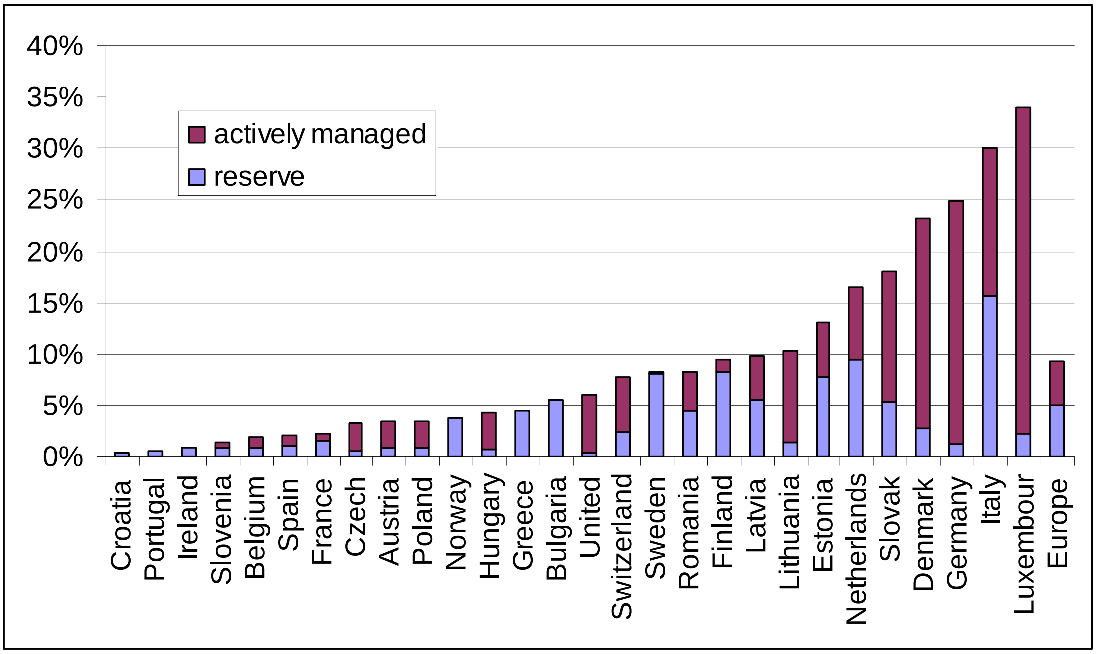


**Figure 1. Share of total forest area that is protected as reserve (MCPFE class 1.1 and 1.2) and actively managed for biodiversity conservation (MCPFE class 1.3) (data after MCPFE, 2007).**

Within the European Union, the Natura 2000 network is the major policy framework for biodiversity conservation. Eventually, this network should cover 10-15% of the EU territory (EU/DG-Environment 2003). Forests are an important part of the Natura 2000 network, with over half of the proposed sites consisting of forested area (EU/DG-Environment 2003).

In this study we combine a global trade model (EFI-GTM; Kallio et al., 2004) with a forest resource projection model (EFISCEN; Schelhaas et al. 2007) to study the effect of policies for biodiversity management on forest resource development, timber trade and harvest in Europe until 2050. We investigated effects of three biodiversity designation levels, ranging from the current 9% of forest area dedicated to biodiversity conservation up to a maximum of 25%. We studied these three levels for two contrasting pictures of global development represented by the IPCC SRES scenarios A1 and B2 (IPCC 2007); hereafter reference futures.

Common indicators for sustainable forest management, including growing stock, age class structure, annual increment and removals, are used to evaluate feedback effects of nature conservation and economic interests on EU forests. The objective is to provide information for policymakers and forest managers to devise policies that harmonize conflicting interests and ensure that objectives of forest conservation and sustainable development are met in the future. This report, however, focuses only on the impacts of different biodiversity designation levels on the recreational value of forests in Europe.

## 2. METHODS

**Models**

In order to predict the outcome of the interacting effects of changes in the global and regional markets for wood and wood products and the regional availability of forest for timber supply a combination of a global trade model (EFI-GTM) and a European forest resource model (EFISCEN) was made. This approach allows for interacting effects of forest development and timber price dynamics on the regional timber harvest in Europe (See Figure 2). With these linked models, projections were made on the sustainability of the use of forest products in six simulation scenarios. These simulation scenarios are combinations of two reference futures with three levels of protected area designation. Sustainability was measured using several indicators of environmental, economic and social sustainability.

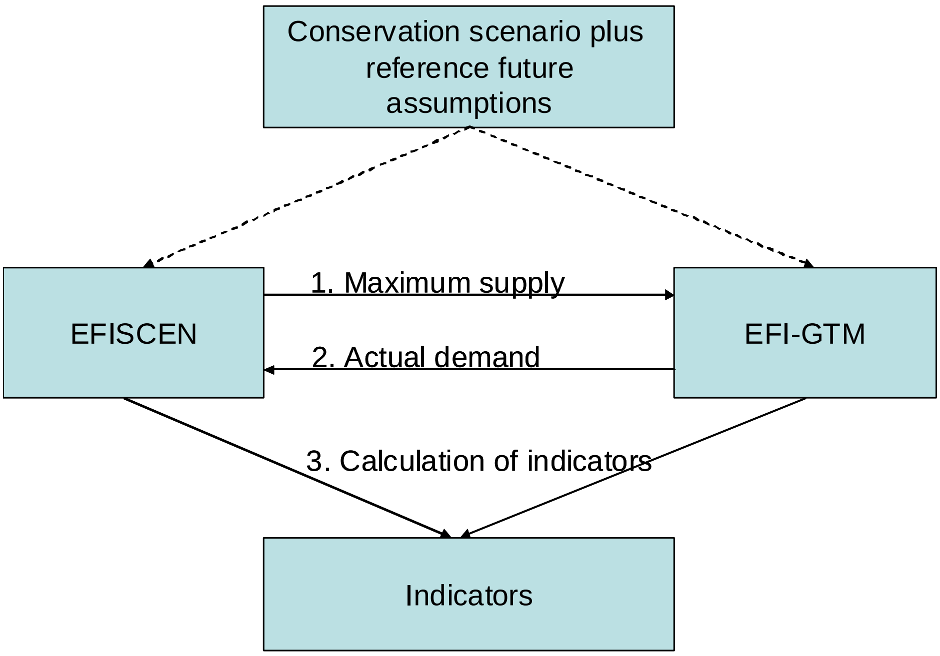


**Figure 2. Schematic overview of information flow between the linked models**

*EFI-GTM*

The European Forest Institute Global Trade Model (EFI-GTM, Kallio et al. 2004) is a partial equilibrium model, focussing on forest products. It makes projections of global consumption, production and trade of forest products, in response to assumed changes in external factors like economic growth, energy prices, trade regulations, transport costs, exchange rates, availability of forest resources, and consumer preferences. The model includes at present 61 regions covering the whole world, with special focus on Europe.

The products modelled currently include six wood categories, 26 forest industry products and four recycled paper grades. The model calculates periodical production, consumption, import and export quantities and product prices for the forest sector products as well as periodical capacity investments of forest industry for each region. The dynamic changes from year to year are modelled by recursive programming. In each period, the producers are assumed to maximize their profits to the production possibility set, while consumers are assumed to maximize their welfare subject to the consumption possibility set. Both producers and consumers are modelled as price takers, i.e. the model assumes competitive markets. More details on the model can be found in Kallio et al. (2004).

*EFISCEN*

The European Forest Information Scenario model (EFISCEN V3.1) is a model that simulates the development of forest resources at scales from provincial to European level (Sallnäs 1990; Schelhaas et al. 2007). Data from National Forest Inventories (NFIs) are used to construct the initial age class distribution and growth function for each combination of province, tree species, site class and owner class that can be distinguished in a country (hereafter referred to as stand type). Each of these stand types is assigned a management regime, which is defined as the probability that a thinning or final harvest can be carried out as a function of stand age. For each five-year time step, the national domestic timber demand has to be defined. This total demand is then supplied from the different stand types, according to the felling possibilities as defined by actual age class distributions and the management regime. Principal outputs of EFISCEN are age class distributions, growing stock volumes, harvesting levels and increment.

*Linking EFI-GTM and EFISCEN*

EFISCEN was used to determine the maximum sustainable harvest level for each of the countries under study for each of the six simulation scenarios, i.e., unique combinations of biodiversity level and reference future. This maximum sustainable level was defined as the maximum harvest level that could be sustained over a period of 100 years. This harvest level was determined in an automatic procedure, for broadleaves and conifers separately. The derived maximum sustainable harvest level per country was then transferred to the EFI-GTM model. Supply curves in the EFI-GTM model were then manually adjusted in order to ensure this level would not be exceeded.

Taking into account the maximum sustainable harvest level, EFI-GTM calculated domestic roundwood demand for each of the six simulation scenarios. This roundwood demand was then used by the EFISCEN model in the simulations of forest development over 100 years and the projected future state of the forest was analysed. A conversion rate of 11% was used to convert underbark roundwood (as used by EFI-GTM) to overbark roundwood (as used by EFISCEN). EFI-GTM only takes into account sawlogs and pulplogs. Actual domestic demand was therefore complemented with the production of other industrial roundwood and fuelwood, as given by FAOSTAT data for 2005 (FAOSTAT 2010). EFI-GTM projected roundwood demand only until 2025. We assumed the demand after 2025 to remain constant at the level of 2025.

**Simulation setup**

*Initial conditions*

EFISCEN was developed for managed forests and is usually applied only to the forest area available for wood supply (FAWS; UN-ECE/FAO 2000) or a comparable forest category. Also the underlying inventory database (Schelhaas et al., 2006b) mostly refers to this definition. However, in order to have a comparable forest area in all simulation scenarios, we extended the area basis to FAWS plus the forest currently classified under MCPFE class 1.1 and 1.2 (no or minimal intervention). We assumed that forest area in MCPFE class 1.3 (managed primarily for biodiversity purposes) is included in the FAWS area. Since no detailed inventory information was available on the forest outside FAWS, we assumed the available FAWS inventory data to be valid for the non-managed areas as well.

We divided the total simulated forest area over three management classes: no management, adapted management and regular management. The actual share of each class depended on the biodiversity designation scenario (see later for explanation). The no-management class is similar to the first forest management alternative (FMA1: unmanaged forest nature reserve) as introduced by Duncker et al. (in prep.). This management was applied to the area under MCPFE classes 1.1 and 1.2 (no or minimal intervention). The adapted-management class is similar to the second forest management alternative (FMA2: close-to-nature forestry) in Duncker et al. This management was applied to the area under MCPFE class 1.3 (actively managed for biodiversity conservation). The regular management class is a combination of forest management alternatives three and four in Duncker et al., i.e., combined objective forestry and intensive even-aged forestry; this was necessary since the regular forest management differed per country. Regular management was simulated as in earlier applications of the model (see Schelhaas et al. 2006a and Nabuurs et al. 2007). For adapted management, rotation lengths were extended by 10 years and the share of thinnings in the total harvest was increased from 33% to 45%. Additionally, half of the felled area of conifers was replanted with broadleaved tree species.

*Reference futures*
We used the IPCC SRES scenarios A1 and B2 as reference futures (Nakicenovic and Swart 2000). Details on the reference futures and their quantification and downscaling to Europe can be found in Arets et al. (in prep.). In both reference futures, we assumed that forests managed under regular management supply cheaper wood than those under adapted management.

The A1 storyline describes a future of rapid economic growth in a globalizing world, with low environmental awareness. Wood demand increases rapidly, in line with the economic growth. For calculating timber demands with EFI-GTM, we assumed that it is cheaper to buy timber on the global market than to harvest it from the area with adapted management in cases where demands could not be met by forests managed under regular management. The latter area was therefore not taken into account in determining the sustainable harvest level for all three simulation scenarios for the A1 reference future.

In the B2 reference future, economic growth is slower, environmental awareness is higher, and there is a greater focus on regional products (IPCC 2007). Although economic growth is lower than in the A1 scenario, wood demand is relatively high, because wood is a renewable resource. Due to increased trade barriers, we assumed it is economically attractive to extract timber from the area with adapted management. In line with the more resourceful B2 reference future, we assumed harvest residue extraction in the regularly managed forest. Residue extraction rates were derived from EEA (2007).

Over the period 1990-2005, the forest area in the countries under study increased by 718.9 thousand hectares per year (MCPFE 2007). The IMAGE-CLUE modelling framework estimated for the period 2000-2030 for A1 an increase of 581.5 thousand hectares per year and for B2 an increase of 604.1 thousand hectares per year. We scaled the projected area change in the period 2000-2030 to the individual countries, using the trend between 1990 and 2005 from MCPFE (2007).

**Simulation scenarios**
In combination with the two reference futures, A1 and B2, we investigated effects of three biodiversity designation levels. For the first level we assumed no change in current designation level, i.e. the baseline, referred to here as ‘A’. Thus there were two baseline scenarios, one for each reference future, A1_A and B2_A. For the next two levels we assumed that all countries increase their designated area in 2005 immediately to at least 15 and 25% of their total forest area. The two scenarios for 15% of forest area were referred to as A1_4 and B2_4. The two scenarios for 25% of forest area were referred to as A1_5 and B2_5. We assumed no changes if the current level of designation in a country already met or exceeded the target. Additionally we assumed that individual countries will retain their current ratio between unmanaged and managed biodiversity protection forest (see Figure 1).

Using 2005 as baseline, we simulated forest development for 100 years to ensure the plausibility of results also in the long-term. Results are presented until the year 2050. The simulations comprised all EU27 countries plus Norway and Switzerland, except Greece, Malta and Cyprus due to a lack of suitable inventory data.

**Recreational value indicator**
In addition to the common forest resource indicators (growing stock, increment, age class distribution, carbon, etc.), the modelling of impacts of Natura 2000 included an indicator on recreation value of the forest developed for four European bioregions. The methodology for deriving the indicator values for each bioregion is given in Edwards et al. (in press) and Edwards et al. (2010).

In brief, scores were obtained for the recreational value of 240 forest stand types across Europe through a Delphi survey involving 46 European participants with experience of forest preference research organised into 4 regional panels: Great Britain, Nordic Region, Central Europe, and Iberia. In each region, 60 forest stand types were defined according to three tree species types (conifer, broadleaved, and mixed), four phases of development (i.e. stand ages: establishment, young, medium and adult), and five forest management alternatives (FMAs) on a continuum from low to high levels of management intensity (forest nature reserves, close-to-nature forests, combined-objective forestry, intensive even-aged forestry, and wood biomass production) (Edwards et al. 2010).

The scores for each bioregion were allocated at the country level across Europe as follows:

- **Great Britain:** England, Scotland, Wales, Northern Ireland, Republic of Ireland, The Netherlands
- **Nordic Region**: Estonia, Finland, Latvia, Lithuania, Norway and Sweden
- **Central Europe:** Austria, Belgium, Bulgaria, Czech Republic, Denmark, France, Germany, Hungary, Luxemburg, Poland, Romania, Slovenia, Slovakia and Switzerland
- **Iberia:** Croatia, Greece, Italy, Portugal and Spain

## 3. RESULTS

For the whole of Europe, the percentage changes in total recreational score between 2005 and 2050 were highly consistent for all six scenarios, ranging from 15.7% for the B2_4 scenario to 18.3% for the A1_4 scenario (see Table 1). The changes in scores/ha over this time period were very small, ranging from 1.0% to 2.9%, again for the B2_4 and A1_4 scenarios respectively. There was a slight increase in the percentage change in total score, and score/ha, as the level of implementation of Natura 2000 increased from 8% (scenarios A1_A and B2_A) to 25% (scenarios A1_5 and B2_5). This increase was slightly higher under the A1 scenarios than under the B2 scenarios.

**Table 1. European forest area, total recreational scores, and scores/ha, in 2005 and 2050 for six scenarios**

| Scenario | Percentage* area of forest designated for conservation | 2005 | | | 2050 | | | % change in total score | % change in score/ha |
|---|---|---|---|---|---|---|---|---|---|
| | | Total forest area (million ha) | Total score | Score/ ha | Total forest area (million ha) | Total score | Score/ ha | | |
| A1_A | 8 | 136,000 | 951,000 | 7.0 | 154,000 | 1,090,000 | 7.1 | 16.5 | 1.9 |
| A1_4 | 15 | 129,000 | 901,000 | 7.0 | 146,000 | 1,038,000 | 7.1 | 17.4 | 2.4 |
| A1_5 | 25 | 121,000 | 840,000 | 6.9 | 137,000 | 982,000 | 7.1 | 18.3 | 2.9 |
| B2_A | 8 | 136,000 | 951,000 | 7.0 | 154,000 | 1,080,000 | 7.0 | 15.7 | 1.0 |
| B2_4 | 15 | 129,000 | 900,000 | 7.0 | 146,000 | 1,028,000 | 7.0 | 16.3 | 1.2 |
| B2_5 | 25 | 121,000 | 839,000 | 6.9 | 137,000 | 968,000 | 7.0 | 16.6 | 1.4 |

* NB: These percentages are estimates. Under the baseline, 9.4% of the simulated forest area was designated as nature conservation area. The other two levels resulted in 17.0 and 25.4% of forest area dedicated to nature conservation.

At the country level there was very little difference in terms of changes to total scores and scores/ha between the scenarios over the 45 year time period. There was however much greater variation in percentage changes over time (see Tables 2 and 3 below, and Tables 4 to 9 in the Appendix). These results are also shown graphically in the maps in Fig 3 below. The discussion below considers possible reasons for the differences between scenarios at European and country level.

**Table 2. Percentage changes in total recreational score between 2005 and 2050 for six scenarios, by country**

| Country | Scenario | | | | | |
|---|---|---|---|---|---|---|
| | A1_A | A1_4 | A1_5 | B2_A | B2_4 | B2_5 |
| Aut | 11.0 | 12.3 | 12.6 | 10.3 | 10.8 | 10.2 |
| Bel | 1.3 | 2.5 | 4.3 | 0.9 | 1.4 | 1.5 |
| Bul | 6.8 | 9.1 | 7.0 | 6.9 | 4.3 | 0.8 |
| Cze | -2.0 | -0.9 | 1.6 | -4.0 | -2.6 | -1.6 |
| Den | 25.1 | 27.0 | 27.5 | 23.4 | 24.7 | 24.6 |
| Est | 16.7 | 15.6 | 14.9 | 15.3 | 14.1 | 12.6 |
| Fin | 3.5 | 3.6 | 6.8 | 0.2 | 1.8 | 4.1 |
| Fra | 10.6 | 10.2 | 10.5 | 10.4 | 9.1 | 9.0 |
| Ger | 6.9 | 6.5 | 6.5 | 4.6 | 4.2 | 4.8 |
| Hun | 35.5 | 35.9 | 36.1 | 35.5 | 35.0 | 35.1 |
| Ire | 59.5 | 63.5 | 64.2 | 59.0 | 63.6 | 64.3 |
| Ita | 31.0 | 31.1 | 31.1 | 31.5 | 31.6 | 31.6 |
| Lat | -13.2 | -12.2 | -8.8 | -14.6 | -13.7 | -12.7 |
| Lit | 12.1 | 11.1 | 10.7 | 10.5 | 8.9 | 8.1 |
| Lux | 8.4 | 9.1 | 9.3 | 8.1 | 8.8 | 8.9 |
| Nla | 18.7 | 18.6 | 18.7 | 18.2 | 18.1 | 17.7 |
| Nor | 9.8 | 9.0 | 9.0 | 8.8 | 7.7 | 7.5 |
| Pol | -0.8 | 3.3 | 3.9 | -1.7 | 1.4 | 1.4 |
| Por | 63.1 | 63.1 | 63.1 | 64.3 | 64.2 | 64.2 |
| Rom | 5.1 | 2.6 | 2.2 | 4.7 | -1.0 | 0.2 |
| Slo | 5.9 | 5.5 | 5.4 | 5.6 | 4.9 | 4.4 |
| Slr | 3.0 | 2.4 | 4.0 | 0.7 | 0.1 | 0.6 |
| Spa | 78.4 | 86.5 | 92.5 | 80.3 | 90.4 | 97.1 |
| Swe | 6.8 | 7.5 | 10.4 | 6.5 | 7.6 | 9.9 |
| Swi | 5.2 | 5.8 | 5.9 | 4.8 | 5.3 | 5.1 |
| Uka | 21.0 | 24.1 | 25.1 | 19.3 | 22.8 | 22.8 |
| **Average** | **16.5** | **17.4** | **18.3** | **15.7** | **16.3** | **16.6** |

**Table 3. Percentage changes in recreational score per hectare between 2005 and 2050 for six scenarios, by country**

| Country | Scenario | | | | | |
|---|---|---|---|---|---|---|
| | A1_A | A1_4 | A1_5 | B2_A | B2_4 | B2_5 |
| Aut | 5.4 | 6.4 | 6.6 | 4.7 | 5.1 | 4.5 |
| Bel | 1.3 | 2.2 | 3.9 | 0.9 | 1.2 | 1.7 |
| Bul | -0.9 | 0.1 | -0.9 | -1.0 | -2.2 | -3.9 |
| Cze | -7.6 | -7.0 | -4.9 | -9.4 | -8.5 | -7.6 |
| Den | 3.7 | 4.9 | 5.2 | 1.8 | 2.5 | 2.5 |
| Est | 3.8 | 2.9 | 2.3 | 2.5 | 1.5 | 0.2 |
| Fin | 2.3 | 2.1 | 4.7 | -0.8 | 0.8 | 2.5 |
| Fra | 0.5 | 0.3 | 0.5 | 0.2 | -0.7 | -0.8 |
| Ger | 1.5 | 1.2 | 1.2 | -0.5 | -0.7 | -0.3 |
| Hun | 8.1 | 8.3 | 8.5 | 7.8 | 7.4 | 7.4 |
| Ire | 9.5 | 11.9 | 12.1 | 8.5 | 11.2 | 11.5 |
| Ita | 7.6 | 7.6 | 7.6 | 7.5 | 7.6 | 7.6 |
| Lat | -13.5 | -12.5 | -9.9 | -14.8 | -14.1 | -13.2 |
| Lit | -1.9 | -2.6 | -3.0 | -3.4 | -4.7 | -5.3 |
| Lux | 6.5 | 7.0 | 7.2 | 6.2 | 6.7 | 6.9 |
| Nla | 8.6 | 8.6 | 8.6 | 8.0 | 7.9 | 7.6 |
| Nor | 3.6 | 2.8 | 2.5 | 2.7 | 1.6 | 1.1 |
| Pol | -5.9 | -2.6 | -2.2 | -6.8 | -4.2 | -4.2 |
| Por | 10.8 | 10.8 | 10.8 | 10.8 | 10.8 | 10.8 |
| Rom | 3.9 | 2.2 | 1.8 | 3.6 | -0.5 | 0.3 |
| Slo | -3.5 | -3.9 | -4.0 | -3.9 | -4.5 | -5.0 |
| Slr | -0.2 | -0.6 | 0.6 | -1.9 | -2.4 | -2.0 |
| Spa | -0.5 | 2.4 | 4.4 | -0.4 | 2.7 | 4.6 |
| Swe | 2.5 | 2.8 | 4.8 | 1.9 | 2.7 | 4.4 |
| Swi | -2.6 | -2.2 | -2.2 | -3.1 | -2.8 | -3.0 |
| Uka | 6.5 | 9.0 | 9.9 | 5.0 | 7.7 | 7.8 |
| **Average** | **1.9** | **2.4** | **2.9** | **1.0** | **1.2** | **1.4** |

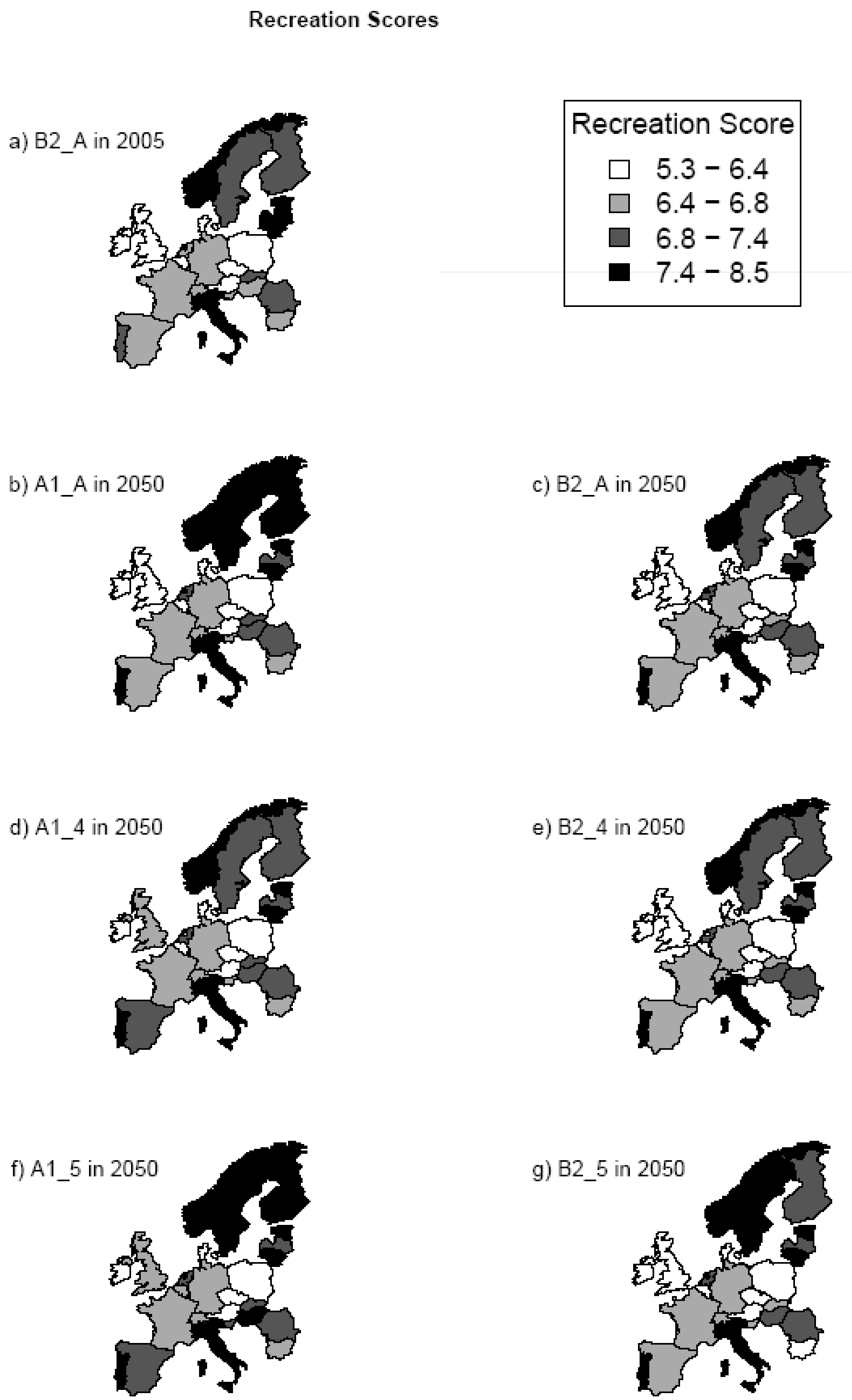


**Figure 3. Recreational scores in 2005 and 2050 for six scenarios, by country**

## 4. DISCUSSION

A number of issues surround the reliability of the results. See Edwards et al. (2010) and Edwards et al. (in press) for a discussion of the strengths and weaknesses of the conceptual framework to derive recreational scores through a Delphi survey. See Schelhaas et al. (in prep.) for a discussion of issues relating to the use of EFISCEN and other models. Taking the results at face value, the following interpretations are offered to explain the impacts of different scenarios on total recreational scores, and scores/ha, at both European and national level. Further interpretation would be possible through more detailed comparison of the changes in scores with the projected inventory data for each scenario in each country.

**European level**

At the European level, the consistent increase in total score between 2005 and 2050 of around 16-18% for all scenarios can be explained largely by a proportionate increase in total area of forest across Europe. Total score and area of forest are closely correlated because all types of forest have a positive score in the scoring system that was used, so an increase in forest area in a given region causes an increase in total score. For example under the A1_A (baseline) scenario, there was a 12.8% increase in forest cover and a 16.5% increase in total score (Table 2). Similarly, under the A1_5 scenario there was a 14.5% increase in forest cover and an 18.3% increase in total score over the 45 year time period. The fact that the increase in total score is slightly higher than the increase in forest cover suggests that other silvicultural changes have also taken place that make a given area of forest slightly more attractive for recreation.

The estimates of score/ha reveal the extent to which these other silvicultural changes may have influenced total scores, because they control for changes in forest area over the 45 year time period. The small increases under all scenarios suggest that the forest has become less intensively managed, and/or that the average age of the forest has increased, since these are the two main factors that lead to high recreational scores (Edwards et al. 2010). The fact that the percentage change in scores/ha increases with an increase in the level of implementation of Natura 2000 can be explained by an overall shift towards less intensive management under higher levels of implementation (e.g. from FMA 3 & 4 to FMA 1 & 2).

**National level**

Regarding total recreational scores at national level, and using the A1_5 scenario as an example, the largest increases in total scores over the 45 year period were found in Spain (92.5%), Ireland (64.2%), Portugal (63.1%), Denmark (27.5%) and UK (25.1%). It appears that these countries were also typically those with the lowest forest cover in 2005 and the largest percentage increases in forest cover over the 45 year period for any given scenario. Thus, the increases in forest cover for these countries were: Spain (84.3%), Ireland (46.3%), Portugal (47%), Denmark (21.0%) and UK (13.8%). Similarly, the largest decreases (or smallest increases) in total scores were found in countries with the highest decrease, or smallest increase in forest cover. The largest decreases, or smallest increases, in total scores were found in: Latvia (-8.8%), Czech Republic (1.6%), Romania (2.2%) and Poland (3.9%). Changes in forest cover were: Latvia (1.2%), Czech Republic (6.9%), Romania (0.4%) and Poland (6.2%).

Regarding scores/ha, again using the A1-5 scenario as an example, the largest increases in score/ha were found in Ireland (12.1%), Portugal (10.8%), UK (9.9%), The Netherlands (8.6%) and Hungary (8.5%) (see Table 3). Some of these countries are among those listed above as also having a large increase in total score, and hence also in total forest area (see Table 2). Yet, an increase in forest area would suggest an increase in the area of younger-aged stands which one might predict would reduce the score/ha. The fact that scores/ha increased over the 45 year period for these countries, despite the increases in new planting, suggests that the forest cover that existed in 2005 was being allowed to increase in maturity over the same time period, thus compensating for the reduction in score/ha caused by new planting. Alternatively, there may have been a greater shift in these countries towards less intensive forms of management. The largest decreases in scores/ha were found in Latvia (-9.9%), Czech Republic (-4.9%), Slovenia (-4.0%), Lithuania (-3.0%) and Poland and Switzerland (-2.2%) (see Table 3). Similarly, some of these countries are among those which had the largest decreases, or smallest increases, in total score.

## 5. CONCLUSIONS

This report builds upon a study carried out by Shelhaas et al. (in prep.) to show how increased nature conservation in European forests affected various sustainability indicators. The authors combined three different nature designation levels with two contrasting pictures of future global development. An increase in nature designation level gave a comparable decrease in maximum sustainable harvest level. Adapted management in part of the designated areas could mitigate about 60% of this reduced harvest potential. Increased nature designation levels had a positive effect on biodiversity and recreation indicators, but more under the A1 reference future than under the B2 reference future. Harvest rates and domestic wood production decreased with increased nature designation, but less under the B2 future than under A1. Schelhaas et al. concluded that with increasing market pressure on the forest, it is increasingly important to take measures to protect biodiversity values.

Regarding impacts on recreational value, it appears that higher levels of implementation of nature conservation policy in forested land would cause a slight increase the recreational value per hectare of forests in Europe over the long term although there are considerable differences between countries. In doing so, the aim of this research has been to demonstrate the potential for inclusion of recreational value in sustainability impact assessments and hence work towards a better balance between the economic, environmental and social pillars of sustainability (MCPFE 2003). The results need to be seen as indicative until further research is conducted to refine the scores on the basis of a larger representative sample of research participants across Europe. It should also be highlighted that the scope of the recreation indicator used in the study is restricted to silvicultural attributes and does not include other factors that may influence recreational value of forests, such as visitor facilities and infrastructure. While efforts to include these non-silvicultural factors may prove to be too ambitious, improvements could be made relatively easily by weighting the recreational scores by an accessibility factor that quantifies the extent to which each forest stand is likely to be visible to the visiting public. These constraints and refinements to the methodology are discussed further in Edwards et al. (2010; in press, and in prep.).

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## APPENDIX

**Table 4. Impacts of the A1_A baseline scenario on recreational scores, by country**

| Country | 2005 | | | 2050 | | | % change in total score | % change in score/ha |
|---|---|---|---|---|---|---|---|---|
| | Total forest area (1000 ha) | Total score | Score/ha | Total forest area (1000 ha) | Total score | Score/ha | | |
| Aut | 3281 | 19279 | 5.9 | 3455 | 21400 | 6.2 | 11.0 | 5.4 |
| Bel | 652 | 3941 | 6.0 | 652 | 3992 | 6.1 | 1.3 | 1.3 |
| Bul | 2615 | 17197 | 6.6 | 2817 | 18363 | 6.5 | 6.8 | -0.9 |
| Cze | 2358 | 14620 | 6.2 | 2502 | 14330 | 5.7 | -2.0 | -7.6 |
| Den | 390 | 2253 | 5.8 | 471 | 2818 | 6.0 | 25.1 | 3.7 |
| Est | 2225 | 16715 | 7.5 | 2501 | 19499 | 7.8 | 16.7 | 3.8 |
| Fin | 20866 | 151927 | 7.3 | 21111 | 157170 | 7.4 | 3.5 | 2.3 |
| Fra | 14819 | 97741 | 6.6 | 16305 | 108118 | 6.6 | 10.6 | 0.5 |
| Ger | 10861 | 70574 | 6.5 | 11440 | 75470 | 6.6 | 6.9 | 1.5 |
| Hun | 1676 | 11274 | 6.7 | 2101 | 15279 | 7.3 | 35.5 | 8.1 |
| Ire | 703 | 3769 | 5.4 | 1024 | 6013 | 5.9 | 59.5 | 9.5 |
| Ita | 10579 | 82689 | 7.8 | 12885 | 108361 | 8.4 | 31.0 | 7.6 |
| Lat | 2906 | 23236 | 8.0 | 2914 | 20157 | 6.9 | -13.2 | -13.5 |
| Lit | 1846 | 14852 | 8.0 | 2108 | 16644 | 7.9 | 12.1 | -1.9 |
| Lux | 88 | 617 | 7.0 | 89 | 669 | 7.5 | 8.4 | 6.5 |
| Nla | 327 | 2168 | 6.6 | 357 | 2574 | 7.2 | 18.7 | 8.6 |
| Nor | 6640 | 51435 | 7.7 | 7037 | 56454 | 8.0 | 9.8 | 3.6 |
| Pol | 8335 | 52382 | 6.3 | 8792 | 51986 | 5.9 | -0.8 | -5.9 |
| Por | 2118 | 14777 | 7.0 | 3117 | 24105 | 7.7 | 63.1 | 10.8 |
| Rom | 4684 | 32055 | 6.8 | 4734 | 33680 | 7.1 | 5.1 | 3.9 |
| Slo | 1160 | 8184 | 7.1 | 1274 | 8667 | 6.8 | 5.9 | -3.5 |
| Slr | 1742 | 11735 | 6.7 | 1797 | 12086 | 6.7 | 3.0 | -0.2 |
| Spa | 9471 | 63378 | 6.7 | 16968 | 113037 | 6.7 | 78.4 | -0.5 |
| Swe | 22398 | 162192 | 7.2 | 23352 | 173291 | 7.4 | 6.8 | 2.5 |
| Swi | 1205 | 8109 | 6.7 | 1302 | 8535 | 6.6 | 5.2 | -2.6 |
| Uka | 2409 | 14342 | 6.0 | 2735 | 17350 | 6.3 | 21.0 | 6.5 |
| **Total** | **136354** | **951442** | | **153841** | **1090048** | | | |
| **Average** | | | **7.0** | | | **7.1** | **16.5** | **1.9** |

**Table 5. Impacts of the A1_4 scenario on recreational scores, by country**

| Country | 2005 | | | 2050 | | | % change in total score | % change in score/ha |
|---|---|---|---|---|---|---|---|---|
| | Total forest area (1000 ha) | Total score | Score/ha | Total forest area (1000 ha) | Total score | Score/ha | | |
| Aut | 3188 | 18922 | 5.9 | 3365 | 21254 | 6.3 | 12.3 | 6.4 |
| Bel | 613 | 3741 | 6.1 | 614 | 3834 | 6.2 | 2.5 | 2.2 |
| Bul | 2362 | 15516 | 6.6 | 2574 | 16927 | 6.6 | 9.1 | 0.1 |
| Cze | 2304 | 14426 | 6.3 | 2457 | 14301 | 5.8 | -0.9 | -7.0 |
| Den | 390 | 2252 | 5.8 | 473 | 2859 | 6.1 | 27.0 | 4.9 |
| Est | 2200 | 16509 | 7.5 | 2470 | 19080 | 7.7 | 15.6 | 2.9 |
| Fin | 19807 | 142933 | 7.2 | 20082 | 148025 | 7.4 | 3.6 | 2.1 |
| Fra | 13491 | 89142 | 6.6 | 14828 | 98261 | 6.6 | 10.2 | 0.3 |
| Ger | 10869 | 70793 | 6.5 | 11437 | 75367 | 6.6 | 6.5 | 1.2 |
| Hun | 1648 | 11235 | 6.8 | 2067 | 15266 | 7.4 | 35.9 | 8.3 |
| Ire | 602 | 3181 | 5.3 | 880 | 5202 | 5.9 | 63.5 | 11.9 |
| Ita | 10579 | 82685 | 7.8 | 12887 | 108424 | 8.4 | 31.1 | 7.6 |
| Lat | 2824 | 22552 | 8.0 | 2831 | 19794 | 7.0 | -12.2 | -12.5 |
| Lit | 1834 | 14738 | 8.0 | 2093 | 16376 | 7.8 | 11.1 | -2.6 |
| Lux | 88 | 615 | 7.0 | 89 | 671 | 7.5 | 9.1 | 7.0 |
| Nla | 327 | 2168 | 6.6 | 357 | 2572 | 7.2 | 18.6 | 8.6 |
| Nor | 5876 | 45211 | 7.7 | 6234 | 49299 | 7.9 | 9.0 | 2.8 |
| Pol | 8102 | 51392 | 6.3 | 8595 | 53111 | 6.2 | 3.3 | -2.6 |
| Por | 1810 | 12633 | 7.0 | 2665 | 20607 | 7.7 | 63.1 | 10.8 |
| Rom | 4504 | 30882 | 6.9 | 4520 | 31672 | 7.0 | 2.6 | 2.2 |
| Slo | 1061 | 7517 | 7.1 | 1165 | 7934 | 6.8 | 5.5 | -3.9 |
| Slr | 1744 | 11777 | 6.8 | 1797 | 12058 | 6.7 | 2.4 | -0.6 |
| Spa | 8713 | 57934 | 6.6 | 15868 | 108026 | 6.8 | 86.5 | 2.4 |
| Swe | 20861 | 150071 | 7.2 | 21814 | 161395 | 7.4 | 7.5 | 2.8 |
| Swi | 1177 | 7956 | 6.8 | 1273 | 8418 | 6.6 | 5.8 | -2.2 |
| Uka | 2393 | 14208 | 5.9 | 2724 | 17634 | 6.5 | 24.1 | 9.0 |
| **Total** | **129367** | **900988** | | **146160** | **1038365** | | | |
| **Average** | | | **7.0** | | | **7.1** | **17.4** | **2.4** |

**Table 6. Impacts of the A1_5 scenario on recreational scores, by country**

| Country | 2005 | | | 2050 | | | % change in total score | % change in score/ha |
|---|---|---|---|---|---|---|---|---|
| | Total forest area (1000 ha) | Total score | Score/ha | Total forest area (1000 ha) | Total score | Score/ha | | |
| Aut | 3108 | 18615 | 6.0 | 3283 | 20956 | 6.4 | 12.6 | 6.6 |
| Bel | 584 | 3605 | 6.2 | 586 | 3761 | 6.4 | 4.3 | 3.9 |
| Bul | 2095 | 13750 | 6.6 | 2263 | 14719 | 6.5 | 7.0 | -0.9 |
| Cze | 2260 | 14290 | 6.3 | 2416 | 14525 | 6.0 | 1.6 | -4.9 |
| Den | 390 | 2260 | 5.8 | 472 | 2881 | 6.1 | 27.5 | 5.2 |
| Est | 2065 | 15441 | 7.5 | 2320 | 17747 | 7.6 | 14.9 | 2.3 |
| Fin | 17922 | 127168 | 7.1 | 18284 | 135852 | 7.4 | 6.8 | 4.7 |
| Fra | 12443 | 82319 | 6.6 | 13684 | 90966 | 6.6 | 10.5 | 0.5 |
| Ger | 10868 | 70798 | 6.5 | 11437 | 75391 | 6.6 | 6.5 | 1.2 |
| Hun | 1622 | 11198 | 6.9 | 2034 | 15240 | 7.5 | 36.1 | 8.5 |
| Ire | 531 | 2777 | 5.2 | 777 | 4559 | 5.9 | 64.2 | 12.1 |
| Ita | 10579 | 82685 | 7.8 | 12887 | 108410 | 8.4 | 31.1 | 7.6 |
| Lat | 2658 | 21128 | 7.9 | 2691 | 19270 | 7.2 | -8.8 | -9.9 |
| Lit | 1809 | 14498 | 8.0 | 2064 | 16044 | 7.8 | 10.7 | -3.0 |
| Lux | 88 | 615 | 7.0 | 89 | 673 | 7.5 | 9.3 | 7.2 |
| Nla | 311 | 2067 | 6.6 | 340 | 2454 | 7.2 | 18.7 | 8.6 |
| Nor | 5199 | 39691 | 7.6 | 5528 | 43252 | 7.8 | 9.0 | 2.5 |
| Pol | 7903 | 50567 | 6.4 | 8395 | 52517 | 6.3 | 3.9 | -2.2 |
| Por | 1599 | 11155 | 7.0 | 2353 | 18196 | 7.7 | 63.1 | 10.8 |
| Rom | 4237 | 29166 | 6.9 | 4253 | 29806 | 7.0 | 2.2 | 1.8 |
| Slo | 989 | 7031 | 7.1 | 1087 | 7413 | 6.8 | 5.4 | -4.0 |
| Slr | 1708 | 11601 | 6.8 | 1765 | 12068 | 6.8 | 4.0 | 0.6 |
| Spa | 8128 | 53756 | 6.6 | 14982 | 103480 | 6.9 | 92.5 | 4.4 |
| Swe | 18604 | 132336 | 7.1 | 19587 | 146078 | 7.5 | 10.4 | 4.8 |
| Swi | 1139 | 7753 | 6.8 | 1233 | 8209 | 6.7 | 5.9 | -2.2 |
| Uka | 2376 | 14065 | 5.9 | 2705 | 17602 | 6.5 | 25.1 | 9.9 |
| **Total** | **121214** | **840336** | | **137517** | **982066** | | | |
| **Average** | | | **6.9** | | | **7.1** | **18.3** | **2.9** |

**Table 7. Impacts of the B2_A baseline scenario on recreational scores, by country**

| Country | 2005 | | | 2050 | | | % change in total score | % change in score/ha |
|---|---|---|---|---|---|---|---|---|
| | Total forest area (1000 ha) | Total score | Score/ha | Total forest area (1000 ha) | Total score | Score/ha | | |
| Aut | 3281 | 19281 | 5.9 | 3455 | 21263 | 6.2 | 10.3 | 4.7 |
| Bel | 652 | 3939 | 6.0 | 652 | 3975 | 6.1 | 0.9 | 0.9 |
| Bul | 2615 | 17200 | 6.6 | 2824 | 18381 | 6.5 | 6.9 | -1.0 |
| Cze | 2358 | 14620 | 6.2 | 2498 | 14030 | 5.6 | -4.0 | -9.4 |
| Den | 387 | 2188 | 5.7 | 470 | 2701 | 5.8 | 23.4 | 1.8 |
| Est | 2225 | 16690 | 7.5 | 2503 | 19242 | 7.7 | 15.3 | 2.5 |
| Fin | 20866 | 151927 | 7.3 | 21062 | 152155 | 7.2 | 0.2 | -0.8 |
| Fra | 14824 | 97757 | 6.6 | 16334 | 107924 | 6.6 | 10.4 | 0.2 |
| Ger | 10834 | 70145 | 6.5 | 11386 | 73383 | 6.4 | 4.6 | -0.5 |
| Hun | 1676 | 11256 | 6.7 | 2107 | 15254 | 7.2 | 35.5 | 7.8 |
| Ire | 704 | 3773 | 5.4 | 1031 | 5997 | 5.8 | 59.0 | 8.5 |
| Ita | 10584 | 82707 | 7.8 | 12943 | 108742 | 8.4 | 31.5 | 7.5 |
| Lat | 2906 | 23236 | 8.0 | 2916 | 19854 | 6.8 | -14.6 | -14.8 |
| Lit | 1843 | 14794 | 8.0 | 2108 | 16342 | 7.8 | 10.5 | -3.4 |
| Lux | 88 | 617 | 7.0 | 89 | 667 | 7.5 | 8.1 | 6.2 |
| Nla | 327 | 2165 | 6.6 | 358 | 2558 | 7.1 | 18.2 | 8.0 |
| Nor | 6641 | 51439 | 7.7 | 7038 | 55976 | 8.0 | 8.8 | 2.7 |
| Pol | 8336 | 52386 | 6.3 | 8792 | 51471 | 5.9 | -1.7 | -6.8 |
| Por | 2120 | 14785 | 7.0 | 3144 | 24285 | 7.7 | 64.3 | 10.8 |
| Rom | 4684 | 32054 | 6.8 | 4731 | 33559 | 7.1 | 4.7 | 3.6 |
| Slo | 1161 | 8185 | 7.1 | 1276 | 8643 | 6.8 | 5.6 | -3.9 |
| Slr | 1738 | 11675 | 6.7 | 1785 | 11755 | 6.6 | 0.7 | -1.9 |
| Spa | 9462 | 63140 | 6.7 | 17125 | 113853 | 6.6 | 80.3 | -0.4 |
| Swe | 22401 | 162199 | 7.2 | 23409 | 172804 | 7.4 | 6.5 | 1.9 |
| Swi | 1206 | 8120 | 6.7 | 1304 | 8513 | 6.5 | 4.8 | -3.1 |
| Uka | 2410 | 14346 | 6.0 | 2739 | 17118 | 6.2 | 19.3 | 5.0 |
| **Total** | **136329** | **950621** | | **154078** | **1080443** | | | |
| **Average** | | | **7.0** | | | **7.0** | **15.7** | **1.0** |

**Table 8. Impacts of the B2_4 scenario on recreational scores, by country**

| Country | 2005 | | | 2050 | | | % change in total score | % change in score/ha |
|---|---|---|---|---|---|---|---|---|
| | Total forest area (1000 ha) | Total score | Score/ha | Total forest area (1000 ha) | Total score | Score/ha | | |
| Aut | 3188 | 18923 | 5.9 | 3363 | 20974 | 6.2 | 10.8 | 5.1 |
| Bel | 612 | 3729 | 6.1 | 613 | 3781 | 6.2 | 1.4 | 1.2 |
| Bul | 2363 | 15529 | 6.6 | 2522 | 16201 | 6.4 | 4.3 | -2.2 |
| Cze | 2304 | 14427 | 6.3 | 2450 | 14046 | 5.7 | -2.6 | -8.5 |
| Den | 387 | 2188 | 5.7 | 471 | 2729 | 5.8 | 24.7 | 2.5 |
| Est | 2199 | 16485 | 7.5 | 2472 | 18805 | 7.6 | 14.1 | 1.5 |
| Fin | 19832 | 143661 | 7.2 | 20037 | 146301 | 7.3 | 1.8 | 0.8 |
| Fra | 13494 | 89110 | 6.6 | 14828 | 97216 | 6.6 | 9.1 | -0.7 |
| Ger | 10837 | 70201 | 6.5 | 11375 | 73175 | 6.4 | 4.2 | -0.7 |
| Hun | 1644 | 11164 | 6.8 | 2067 | 15076 | 7.3 | 35.0 | 7.4 |
| Ire | 603 | 3186 | 5.3 | 887 | 5212 | 5.9 | 63.6 | 11.2 |
| Ita | 10584 | 82701 | 7.8 | 12945 | 108806 | 8.4 | 31.6 | 7.6 |
| Lat | 2822 | 22514 | 8.0 | 2835 | 19431 | 6.9 | -13.7 | -14.1 |
| Lit | 1831 | 14663 | 8.0 | 2090 | 15964 | 7.6 | 8.9 | -4.7 |
| Lux | 88 | 616 | 7.0 | 89 | 670 | 7.5 | 8.8 | 6.7 |
| Nla | 327 | 2165 | 6.6 | 358 | 2556 | 7.1 | 18.1 | 7.9 |
| Nor | 5877 | 45213 | 7.7 | 6231 | 48711 | 7.8 | 7.7 | 1.6 |
| Pol | 8103 | 51384 | 6.3 | 8580 | 52127 | 6.1 | 1.4 | -4.2 |
| Por | 1812 | 12640 | 7.0 | 2688 | 20760 | 7.7 | 64.2 | 10.8 |
| Rom | 4504 | 30872 | 6.9 | 4482 | 30564 | 6.8 | -1.0 | -0.5 |
| Slo | 1062 | 7519 | 7.1 | 1167 | 7889 | 6.8 | 4.9 | -4.5 |
| Slr | 1740 | 11720 | 6.7 | 1785 | 11733 | 6.6 | 0.1 | -2.4 |
| Spa | 8616 | 56626 | 6.6 | 15983 | 107838 | 6.7 | 90.4 | 2.7 |
| Swe | 20868 | 150201 | 7.2 | 21863 | 161615 | 7.4 | 7.6 | 2.7 |
| Swi | 1178 | 7968 | 6.8 | 1275 | 8387 | 6.6 | 5.3 | -2.8 |
| Uka | 2395 | 14215 | 5.9 | 2729 | 17451 | 6.4 | 22.8 | 7.7 |
| **Total** | **129269** | **899619** | | **146186** | **1028023** | | | |
| **Average** | | | **7.0** | | | **7.0** | **16.3** | **1.2** |

**Table 9. Impacts of the B2_5 scenario on recreational scores, by country**

| Country | 2005 | | | 2050 | | | % change in total score | % change in score/ha |
|---|---|---|---|---|---|---|---|---|
| | Total forest area (1000 ha) | Total score | Score/ha | Total forest area (1000 ha) | Total score | Score/ha | | |
| Aut | 3108 | 18615 | 6.0 | 3283 | 20956 | 6.4 | 10.2 | 4.5 |
| Bel | 584 | 3605 | 6.2 | 586 | 3761 | 6.4 | 1.5 | 1.7 |
| Bul | 2095 | 13750 | 6.6 | 2263 | 14719 | 6.5 | 0.8 | -3.9 |
| Cze | 2260 | 14290 | 6.3 | 2416 | 14525 | 6.0 | -1.6 | -7.6 |
| Den | 390 | 2260 | 5.8 | 472 | 2881 | 6.1 | 24.6 | 2.5 |
| Est | 2065 | 15441 | 7.5 | 2320 | 17747 | 7.6 | 12.6 | 0.2 |
| Fin | 17922 | 127168 | 7.1 | 18284 | 135852 | 7.4 | 4.1 | 2.5 |
| Fra | 12443 | 82319 | 6.6 | 13684 | 90966 | 6.6 | 9.0 | -0.8 |
| Ger | 10868 | 70798 | 6.5 | 11437 | 75391 | 6.6 | 4.8 | -0.3 |
| Hun | 1622 | 11198 | 6.9 | 2034 | 15240 | 7.5 | 35.1 | 7.4 |
| Ire | 531 | 2777 | 5.2 | 777 | 4559 | 5.9 | 64.3 | 11.5 |
| Ita | 10579 | 82685 | 7.8 | 12887 | 108410 | 8.4 | 31.6 | 7.6 |
| Lat | 2658 | 21128 | 7.9 | 2691 | 19270 | 7.2 | -12.7 | -13.2 |
| Lit | 1809 | 14498 | 8.0 | 2064 | 16044 | 7.8 | 8.1 | -5.3 |
| Lux | 88 | 615 | 7.0 | 89 | 673 | 7.5 | 8.9 | 6.9 |
| Nla | 311 | 2067 | 6.6 | 340 | 2454 | 7.2 | 17.7 | 7.6 |
| Nor | 5199 | 39691 | 7.6 | 5528 | 43252 | 7.8 | 7.5 | 1.1 |
| Pol | 7903 | 50567 | 6.4 | 8395 | 52517 | 6.3 | 1.4 | -4.2 |
| Por | 1599 | 11155 | 7.0 | 2353 | 18196 | 7.7 | 64.2 | 10.8 |
| Rom | 4237 | 29166 | 6.9 | 4253 | 29806 | 7.0 | 0.2 | 0.3 |
| Slo | 989 | 7031 | 7.1 | 1087 | 7413 | 6.8 | 4.4 | -5.0 |
| Slr | 1708 | 11601 | 6.8 | 1765 | 12068 | 6.8 | 0.6 | -2.0 |
| Spa | 8128 | 53756 | 6.6 | 14982 | 103480 | 6.9 | 97.1 | 4.6 |
| Swe | 18604 | 132336 | 7.1 | 19587 | 146078 | 7.5 | 9.9 | 4.4 |
| Swi | 1139 | 7753 | 6.8 | 1233 | 8209 | 6.7 | 5.1 | -3.0 |
| Uka | 2376 | 14065 | 5.9 | 2705 | 17602 | 6.5 | 22.8 | 7.8 |
| **Total** | **121214** | **840336** | | **137517** | **982066** | | | |
| **Average** | | | **6.9** | | | **7.1** | **16.6** | **1.4** |