EFORWOOD
Tools for Sustainability Impact Assessment

Research protocol to derive recreational scores for European forest management alternatives

David Edwards, Mariella Marzano, Marion Jay, Frank Jensen, Beatriz Lucas, Bill Mason, Claire Montagne, Andy Peace and Gerhard Weiss

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Preface

This report is a deliverable from the EU FP6 Integrated Project EFORWOOD – Tools for Sustainability Impact Assessment of the Forestry-Wood Chain. The main objective of EFORWOOD was to develop a tool for Sustainability Impact Assessment (SIA) of Forestry-Wood Chains (FWC) at various scales of geographic area and time perspective. A FWC is determined by economic, ecological, technical, political and social factors, and consists of a number of interconnected processes, from forest regeneration to the end-of-life scenarios of wood-based products. EFORWOOD produced, as an output, a tool, which allows for analysis of sustainability impacts of existing and future FWCs.

The European Forest Institute (EFI) kindly offered the EFORWOOD project consortium to publish relevant deliverables from the project in EFI Technical Reports. The reports published here are project deliverables/results produced over time during the fifty-two months (2005–2010) project period. The reports have not always been subject to a thorough review process and many of them are in the process of, or will be reworked into journal articles, etc. for publication elsewhere. Some of them are just published as a "front-page", the reason being that they might contain restricted information. In case you are interested in one of these reports you may contact the corresponding organisation highlighted on the cover page.

Uppsala in November 2010

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EFORWOOD

Sustainability Impact Assessment of the Forestry - Wood Chain

Project no. 518128

EFORWOOD

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PD2.3.5: Research protocol to derive recreational scores for European forest management alternatives

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ABSTRACT

This deliverable presents the research protocol for the Delphi survey that is being used to derive scores to assess the recreational value of 240 forest stand types in four European regions: upland areas of Great Britain, Boreal areas of the Nordic Region, Central Europe, and Mediterranean areas of Iberia. The scores will contribute to a European synthesis of public perceptions of the recreational value of forests (EFORWOOD D2.3.3 and D2.3.6). They will also be combined with outputs from the European forest resource projection model, 'EFISCEN', to estimate current and future recreational values under different scenarios (EFORWOOD D2.3.7). A concluding section outlines the timing of the survey and final steps for the WP2.3 research agenda. The questionnaire used for the Great Britain survey is included as an appendix.

CONTENTS

1. INTRODUCTION

This deliverable presents the research protocol that is being used to derive scores to assess the recreational value of 240 forest stand types throughout Europe. A Delphi method is being used to obtain the scores in four European regions: a) upland areas of Great Britain (Scotland, Wales and England), b) Boreal areas of the Nordic Region (Norway, Sweden and Denmark), c) Central Europe (southern Germany, Austria and Switzerland), and Mediterranean areas of Iberia (Spain and Portugal). The scores will contribute to a European synthesis of public perceptions of the recreational value of forests (EFORWOOD D2.3.3 and D2.3.6. See also Edwards *et al*,. 2009 in press). They will also be combined with outputs from the European forest resource projection model, 'EFISCEN', using the conceptual framework described in PD2.3.4 (Edwards *et al*. 2008; cf. Edwards *et al.,* 2009), to estimate current and future recreational values under different scenarios, for example implementation of new policies for biodiversity conservation or bioenergy production (EFORWOOD D2.3.7).

The following sections provide a stepwise description of the approach that will be used, drawn from Edwards *et al*. (2009 in press). A final section provides concluding remarks and next steps for completion of the EFORWOOD WP2.3 research programme. The full questionnaire to be used in the Great Britain survey is included as an appendix.

2. DERIVING RECREATIONAL SCORES USING A DELPHI METHOD

Delphi is a social research technique that seeks to provide a reliable group opinion on how to solve a complex problem through the use of expert judgement (Landeta, 2006, p. 468; cf. Linstone and Turoff, 1975, p. 3). Typically, a panel of experts is invited to participate anonymously in a questionnaire survey. Questions are structured in a way that allows participants to rank, or select from, a continuum of possible answers, thereby allowing the group statistical response to be analysed. After the first round of responses has been received, the results are summarised by the survey monitor, and the survey is redistributed to each panel member who is given the opportunity to revise their original answers in the light of the full set of anonymous responses. The process undergoes one or more iterations until stability in the responses is reached. Often, but not always, the responses converge towards a position of consensus (Gordon, 1994, p. 3).

The classic application of Delphi is to forecast future developments (Linstone and Turoff, 1975). Recently its use has been extended to encompass the kinds of questions being addressed here, namely to obtain values for independent variables for use in quantitative simulation models that would be too expensive to derive through questionnaire surveys (Gordon 1994, p. 4). For example, Curtis (2004) used Delphi for valuation of ecosystem goods and services, while Landeta *et al*. (2002) used Delphi to estimate expenditure by tourists to provide inputs for a model to assess the economic value of tourism in Catalonia. The method was seen by Landeta (2006, p. 476) to produce data of "equal or greater quality than those obtained by means of traditional surveys" and certainly at a lower financial cost.

Use of the Delphi method is proposed here as a means to derive the recreational scores in four case studies that represent the four European regions identified above (cf. Pröbstl *et al*., 2009). The steps required are summarised in the following table, and described below, based upon the protocol for the Delphi method developed by Novakowski and Wellar (2008).

2.1 Preparation for the survey

Step 1: Identify and address knowledge gaps
As part of EFORWOOD WP2.3, the literature on forest preference research in Europe was reviewed to explore the contribution of different silvicultural attributes to the overall recreational value of European forests (Edwards *et al.*, 2009, in prep.). The review developed a typology of attributes and summarised their respective contributions to recreational value across different geographical regions, social groups, and recreational activities. The conclusions of the review have been summarised in a

table that will be included in the questionnaire to support experts' scoring decisions (see step 3 and Appendix 1).

Steps for obtaining recreational scores using the Delphi method

Preparation for the survey
1. Identify and address knowledge gaps
2. Ensure Delphi is the most appropriate research instrument
Survey design
3. Preparation of draft background report and survey
4. Establish criteria for recruitment of participants
5. Select and contact participants
6. Trial run
7. Final revision of background report and survey
Survey implementation
8. Round 1: distribution of report and survey
9. Incorporation of feedback from round 1
10. Round 2: redistribution of survey
11. Incorporation of feedback from previous round [Return to step 10 until stability is reached]
Analysis of results
12. Final tabulation of responses
13. Analysis of final results
Dissemination to participants
14. Anonymous post-Delphi survey
15. Dissemination of research results

Source: Adapted from 'Flowchart for a normative Delphi' (Novakowski and Wellar, 2008, p. 1488).

Step 2: Ensure Delphi is the most appropriate research instrument
Two alternatives to Delphi were considered. First, a traditional questionnaire could be used to ask similar experts a similar set of questions but without providing an opportunity to revise their responses in the light of other panel members' anonymous responses. This method may reduce the potential risks associated with fatigue on the part of participants who can feel used or frustrated by a poorly designed survey (Landeta, 2006, p. 470). It was decided that the benefits gained by iterative refinements to the results were likely to outweigh such risks. Secondly, a workshop could be organised where experts are invited to answer similar questions as part of a facilitated group exercise. Delphi was preferred because of the advantages of eliciting anonymous responses, in particular the reduced risk that dominant individuals may distort the outcomes of the survey (Landeta, 2006, p. 469).

2.2 Survey design

Step 3: Preparation of draft background report and survey
To apply the survey across Europe, four Delphi panels will be assembled, one for each of the regions identified above (Great Britain, the Nordic Region, Central Europe and Iberia). For each panel a separate questionnaire is used, comprising three matrices, one for the most common conifer species, one for the most common broadleaved species and one for mixed stands. Each matrix has 20 cells representing the five FMAs and four phases of development. Such a survey design generates a total of 240 scores in 12 matrices, although a small proportion of these will not be applicable according to the precise regional definitions of each FMAs. Participating experts are asked to fill in the cells with a score on a ten-point scale to indicate how they believe potential visitors would value a forest stand of that type as a location for recreational use (assuming that there was suitable physical access into, alongside, or in close proximity to the stand). They are asked to use the full range of scores from 1-10, to standardise the way in which the scale is interpreted by different participants. They are also asked to provide explanatory notes on the decisions that they make, and to rate their confidence levels for each matrix (or component of each matrix) which could then be used to weight their respective

contributions. It has been suggested that this can produce more accurate results (Novakowski and Wellar, 2008, p. 1492).

The scoring process is supported by means of background information providing a common knowledge base for all participants and comprising three elements. First, a table is provided as part of the survey questionnaire, which summarises the European literature review of public preferences for silvicultural attributes (Edwards *et al*., 2009, in prep.). In one of the questions, experts are asked to indicate the importance of each attribute to the overall recreational value of forests in their case study area. Experts are also invited to use the table to support their decisions on scores for stand types. In addition, a brief appendix provides a brief generic description of each FMA.

Step 4: Establish criteria for recruitment of participants
In accordance with other reported surveys, it is proposed that around ten participants are sought for each panel (Novakowski and Wellar, 2008, p. 1491). This figure represents a trade-off between the reliability of the results and the cost of experts' time. Experts are defined here according to two key criteria: a) those who are able to complete the survey competently on behalf of the forests in a given region on the basis of the background information provided, in particular the use of verbal descriptions rather than images as a means to conceptualise each forest stand, and b) those who are able to answer competently on behalf of potential visitors to forests in a given region, for example by taking into account regional cultural preferences and the more negative attitudes of the public towards the effects of intrusive silvicultural interventions outlined in section 2.4. These criteria are likely to be met primarily among experts who have carried out forest preference research in their respective region. If sufficient individuals cannot be found for any given panel, then further members will be sought, primarily from among forest recreation researchers and managers, and judgements made on a case-by-case basis of their ability to meet the two criteria (cf. Gordon, 1994, pp. 11-12).

Step 5: Select and contact participants
The selected participants in each region are then invited to participate, and asked to suggest other potential participants who might be suitable (Novakowski and Wellar, 2008, p. 1491).

Step 6: Trial run
Next, a trial run is carried out with an additional small panel of participants who satisfy the two key criteria, with representation from each of the four regions, who are asked to complete the draft survey questionnaire on the basis of the draft background information, and provide critical comments on its clarity and completeness and allow for final alterations to be made (Novakowski and Wellar, 2008, p. 1492).

Step 7: Final revision of the background report and survey
The survey questionnaire is then revised in the light of comments from the trial run (Novakowski and Wellar, 2008, p. 1492).

2.3 Survey implementation

Step 8: Round 1: distribution of report and survey
The questionnaire is then circulated to participants, with a deadline for completion (Novakowski and Wellar, 2008, p. 1492).

Step 9: Incorporation of feedback from round 1
The survey monitors then collate and analyse the results; if necessary the questionnaire is revised, and feedback is prepared. An initial analysis is carried out separately for each region, and involves calculating the average (median) scores provided by all experts (Gordon, 1994, p. 8). Feedback provided in round 2 consists of: a) the average score (and possibly also the entire set of scores) from round 1, and b) a summary (or possibly a full account) of the qualitative feedback provided to explain the decisions behind scores and comments on the survey design. The questionnaire may also be refined in the light of comments in round 1 (Novakowski and Wellar, 2008, p. 1493).

Step 10: Round 2: redistribution of the survey
During round 2, participants are given the opportunity to reconsider their initial responses in the light of the anonymised scores and supporting comments of others in the previous round. Depending upon previous responses, participants may be asked again to explain their decisions for their scores only if they fall a certain distance from the median response (cf. Novakowski and Wellar, 2008, p. 1493).

Step 11: Incorporation of feedback from previous round
Reactions to the feedback from previous rounds may cause participants' scores to converge, although the goal of the survey is stability of individual responses between rounds rather than a given level of consensus (Novakowski and Wellar, 2008, p. 1494; Gordon 1994, p. 4). One or more additional rounds may be carried out until stability is reached, i.e. when the proportion of individual participants who changed their response falls to a certain level for example 20% or less (Nelson, 1978, p. 45 in Novakowski and Wellar 2008, p. 1494). According to Linstone and Turoff (1975a, p. 229) three rounds are usually sufficient.

2.4 Analysis of results

Step 12: Final tabulation of responses
Once stability is reached no further rounds are carried out and the results are tabulated.

Step 13: Analysis of final results
The degree of consensus between participants for a given forest stand type is then calculated and expressed in terms of the deviations from the median score, i.e. standard error. A non-parametric technique such as boot strapping is used since the distributions of scores for a given cell are unknown. The standard error can be used to estimate confidence intervals for the overall recreational value of forests in the region (see Edwards et al., 2008 – i.e. PD2.3.4 – for the theoretical framework to derive recreational value for all forests in a given region). The broad distribution in scores may also be recorded according to the following classes: consensus, majority, bimodality, bipolarity, plurality and disagreement (Novakoswki and Wellar, 2008, p. 1495) with an explanation for the distribution drawn from participants' qualitative feedback. The scores for each of the four proposed European regions are then used to explore the extent to which they are significantly different from those in other regions (i.e. whether the sum of deviations from the median score for each forest stand type is greater within or between the regions).

2.5 Dissemination to participants

Step 14: Anonymous post-Delphi survey
An anonymous evaluation of the survey is carried out to give participants an opportunity to share their views on the reliability of the final results, and on how the survey process might be improved as part of similar research in the future (Novakowski and Wellar, 2008, p. 1495). An opportunity may now be given for individual participants to reveal their identity to the rest of the panel (Novakowski and Wellar, 2008, p. 1497).

Step 15: Dissemination of research results
A summary of the research results and conclusions is prepared and circulated to monitors and panel members, along with formal letters of thanks (Novakowski and Wellar, 2008, p. 1497).

3. CONCLUSIONS AND FINAL STEPS

Once the recreational scores are obtained for each forest stand type in each case study, the current total recreational value for all forests in a given region can be estimated using outputs from EFISCEN. Similarly, changes to the total recreational value can be forecasted under different scenarios. The conceptual framework for such analyses is illustrated in PD2.3.4 (Edwards *et al.,* 2008, cf. Edwards *et al*., 2009 in press).

Currently the WP2.3 team is at Step 6, i.e. the 'trial run' or pilot stage in the process described above. Comments will be incorporated, and final changes made to the questionnaire (see Appendix), which will then be circulated to the four panels of experts. Different members of the WP2.3 team are responsible for managing each panel, depending upon their location in Europe. The aim is to complete the survey by the end of September 2009.

The scores will then be analysed and used to complete the remaining EFORWOOD deliverables:

- **D2.3.3** 'Public preferences for silvicultural attributes of European forests' (postponed from Month 36);
- **D2.3.6** 'Assessment of the recreational value of European forest management alternatives' (due in Month 48), and
- **D2.3.7** 'Modelling the impacts of forest management alternatives on recreational values in Europe (due in Month 48).

Preparation of D2.3.7 will require collaboration with colleagues in WP2.5 so that the scores can be combined with outputs from EFISCEN across Europe to demonstrate the impacts of a number of future scenarios, such as different levels of implementation of the Natura 2000 policy for biodiversity conservation, and policies to enhance bioenergy production for climate change mitigation. This work would complete the WP2.3 research programme, and should lead to two journal articles for submission at the end of 2009 to the Special Issue of Ecology and Society featuring the work of EFORWOOD Module 2.

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Appendix: Sample questionnaire used for the Great Britain survey

EFORWOOD
Sustainability Impact Assessment
of the Forestry - Wood Chain

A Delphi survey to assess the recreational value of forests in upland areas of Great Britain

Your Name: _____

This survey aims to quantify the recreational value of different forest types that may be found in upland areas of Great Britain. It is one of four surveys being carried out in four regions located across Europe. The surveys focus on the most common conifer and broadleaved tree species growing in each region. For Great Britain, these are Sitka spruce (*Picea sitchensis*) and birch (*Betula* spp.).

The 'recreational value' of a forest is defined here in terms of the preferences of people who regularly use forests as sites for recreation (i.e. 'forest visitors'). Their preferences for a given forest are likely to be influenced by many factors, but this survey is concerned *only* with silvicultural attributes (tree size, stand density, species composition, etc). For most visitors, these are important because they affect the visual attractiveness of the forest. However, some visitors may also value the same attributes for non-aesthetic reasons, e.g. because they provide better habitats for hunting, bird-watching, or collection of mushrooms and berries. When completing the questions, try to take these differences into account, and answer on behalf of the 'average' visitor.

QUESTION 1: SILVICULTURAL ATTRIBUTES

(a) For each attribute listed in the table below, please indicate whether its relationship to the recreational value of the forests in your region is best described as: positive, negative, bell-shaped, U-shaped, or even (see graphs below). For example, for 'attribute 1', if you think recreational value increases when 'stand age' increases from establishment to maturity, please write 'P' for 'positive' in the first column.

(b) For each attribute, please assign a weighting, on a scale from 1 (low) to 10 (high), to indicate its relative contribution to the overall recreational value of the forests in your region. IMPORTANT: Use the full range of weightings from 1-10. Use the same weighting for different attributes if appropriate.

(c) For each attribute, indicate your level of confidence in your answers for 'a' and 'b' (low, medium, or high).

Please provide any comments and explanations for your answers in the box provided on the following page.

Relationships between silvicultural attributes and recreational values

	**Positive** Recreational value increases when the level of the attribute increases from low to high
	**Negative** Recreational value decreases when the level of the attribute increases from low to high
	**Bell-shaped** Recreational value is enhanced by the attribute, except when the level of the attribute is very low or very high
	**U-shaped** Recreational value is reduced by the attribute, except when the level of the attribute is very low or very high
	**Even** Recreational value is not affected by the level of the attribute

Please fill in each column (a, b and c) as described above:

Silvicultural attribute	(a) **Relationship** Select from: '**P**ositive', '**N**egative', '**B**ell-shaped', '**U**-shaped' or '**E**ven'	(b) **Relative contribution** Select from: **1** (=lowest) to **10** (=highest)	(c) **Confidence rating** Select from: '**L**ow', '**M**edium' or '**H**igh'
1. Size of trees within stand • Stand age: from establishment to maturity • Canopy height: from low to high			
2. Variation in tree size within stand • Variation in tree size: from uniform to diverse • Number of canopy layers: from one to many			
3. Variation in tree spacing within stand • Variation in tree spacing: from regular to different sized groups of trees and openings			
4. Extent of tree cover within stand • Tree cover: from sparse (i.e. retention and seed trees) to moderate (e.g. shelterwood and selection systems) to full (i.e. closed canopy)			
5. Visual penetration through stand • Distance visible: from short to long • Understorey and shrub layer: from dense to absent			
6. Density of ground vegetation cover up to 50 cm height within stand • Ground cover: from absent to dense			
7. Number of tree species within stand • Number of species: from one to many			
8. Size of clear-cuts • Size of clear-cuts: from small to large			
9. Residue from harvesting and thinning • Volume of tree stumps, branches and other visible woody residue: from low to high			
10. Amount of natural deadwood (standing and fallen) • Volume of deadwood: from low to high			
11. Variation *between* stands along a 5 km trail through forest • Number of forest stand types* encountered: from one to many			
12. 'Naturalness' of forest edges • Proportion of 'natural' looking (i.e. not straight) edges: from low to high			

* 'Forest stand types' differ according to stand age, management regime, and/or tree species composition.

Comments on Question 1:

QUESTION 2: FOREST STAND TYPES

The scoring sheet below consists of three matrices representing forest stands with three different tree species compositions: a) Sitka spruce, b) birch, and c) mixed (i.e. Sitka spruce and birch). Each matrix has 20 cells representing five forest management alternatives (FMAs) and four phases of development (establishment, young, medium and adult).

The five FMAs lie on a continuum from non-intervention to intensive production, as follows. They have common definitions across Europe (see appendix).

1. Forest nature reserves
2. Close-to nature forestry
3. Combined objective forestry
4. Intensive even-aged forestry
5. Wood biomass production

The four phases of development are defined as follows:

1. **Establishment:** 0–5 years: less than 2 metres in height.
2. **Young:** 5–15 years: between 2 metres, and up to 7 cm breast height diameter (DBH).
3. **Medium:** 15–50 years: up to when most height growth has been reached.
4. **Adult:** 50+ years: after the time when most height growth has been reached.

Using the score sheet below, please fill in each cell with a score, on a scale from 1 (lowest) to 10 (highest), to indicate how you believe the average visitor would value a forest stand of that type as a location for recreation in your region. Please provide comments or explanations for your answers in the box provided on the following page.

PLEASE READ CAREFULLY!

- **Important:** Use the full range of scores from 1 to 10 across the whole score sheet. However, each matrix may have a different range of scores (e.g. 1-10, 2-8, 4-10) if you think that forests of different species have different overall values.

- **Tip:** First identify the stand(s) with '1' and the stand(s) with '10' across the whole score sheet. Then identify the remaining highest and lowest stands within each matrix. Then fill in all the other scores.

- Use full numbers (i.e. no decimals or fractions). Use the same score for different forest stand types if you feel they are of equal recreational value.

- Assume that there is suitable physical access into, alongside, or in close proximity to the stand from which a visitor could judge its recreational value.

- Base your scores on bio-physical features only: ignore paths and other recreational infrastructure that may be present in such a forest type.

- Please provide a score for every cell, even though in practice some may be extremely rare, e.g. 'adult FMA5' or 'establishment FMA1'.

- Try to provide average scores across all seasons of the year to allow for differences in appearance of deciduous trees and due to snowfall, etc.

- When scoring 'establishment phase' stands, remember that neighbouring stands may also be visible. Assume that these are of the same FMA.

- It may help to refer to your weightings for the attributes in the table above (question 1), and to the descriptions of FMAs in the appendix.

Score sheet: Great Britain

A) SITKA SPRUCE

Phase of development	Forest management alternative (FMA)				
	1. Forest nature reserves	2. Close-to-nature forests	3. Combined objective forestry	4. Intensive even-aged forestry	5. Wood biomass production
1. Establishment					
2. Young					
3. Medium					
4. Adult					

B) BIRCH

Phase of development	Forest management alternative (FMA)				
	1. Forest nature reserves	2. Close-to-nature forests	3. Combined objective forestry	4. Intensive even-aged forestry	5. Wood biomass production
1. Establishment					
2. Young					
3. Medium					
4. Adult					

C) MIXED (SITKA SPRUCE AND BIRCH)

Phase of development	Forest management alternative (FMA)				
	1. Forest nature reserves	2. Close-to-nature forests	3. Combined objective forestry	4. Intensive even-aged forestry	5. Wood biomass production
1. Establishment					
2. Young					
3. Medium					
4. Adult					

Comments on Question 2 (if relevant, also indicate your level of confidence in particular scores):

Please email your completed questionnaire, and any queries you may have, to:
David Edwards, Social and Economic Research Group, Forest Research, Northern Research Station, Roslin, Scotland EH25 9SY. Tel: +44 (0)131 445 8495. **david.edwards@forestry.gsi.gov.uk**

Thank you for participating in the survey.

If you would like a copy of the final report, please type 'YES' in the textbox:

APPENDIX
Descriptions of Forest Management Alternatives (FMAs)

1. Forest nature reserve
The main objective of forest nature reserves is to allow natural processes and natural disturbance regimes to develop to create natural ecologically valuable habitats. They are typically protected by an ordinance or forest act. No operations are allowed that might change the nature of the area. Possible operations may include construction of visitor trails, and limited measures to protect against external factors such as fire.

2. Close-to-nature forestry
The main objective is to manage each stand with the emulation of natural processes as a guiding principle. Financial return is important, but management interventions must enhance or conserve the ecological functions of the forest. Timber can be harvested and extracted, but some standing and fallen dead wood is left, which may reduce productivity. Only native or site adapted tree species are chosen. Natural regeneration is preferred. The rotation length is generally much longer than the age of maximum mean annual volume increment (MMAI) and harvesting uses small scale removals resulting in the development of an irregular and intimately mixed stand structure.

3. Combined objective forestry
Management pursues a combination of economic (timber production) and non-market objectives. Mixtures of tree species are often promoted, comprising both native and introduced species suitable for the site. Natural regeneration is preferred, but planting or direct seeding may also be used. Site cultivation and/or fertilization may be carried out. The rotation length is either similar to (in conifers) or longer than (broadleaves) the age of MMAI and the harvesting system is generally designed around small scale clear felling with groups of trees retained for longer periods to meet landscape and biodiversity objectives. This management alternative is also referred to as 'multiple-use forestry'.

4. Intensive even-aged forestry
The main objective is to produce timber, although landscape and biodiversity may feature as secondary objectives. Typical stands tend to be even-aged, and composed of one or very few species. Any species can be suitable provided it is site-adapted and non-invasive. Planting, seeding or natural regeneration are all possible depending upon which option is most economic. Intensive site management including cultivation and weed control is used to ensure rapid establishment. Genetically improved material is often planted where available. The rotation length is often less than or similar to the age of MMAI. Clear felling is normal practice or in some countries a combination of shelterwood and clear-cut is applied if natural regeneration is more economic. Whole tree harvesting may occur but residues are normally left on site.

5. Wood biomass production
The main objective is to produce the highest amount of small dimension wood biomass or fibre. Tree species selection depends mainly on the economic return, as long as the species is not invasive. Pure stands of single species are generally favoured. Intensive site management may occur to ensure rapid canopy closure. The rotation period is short: typically from 5-25 years depending on species characteristics and the economic return. The intensity of harvesting is at its maximum compared to the other alternatives. The final felling is a clear-cut with removal of all woody residue, and even the stumps if there is a suitable market. Management can resemble traditional coppicing.