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MOTIVE

Models for Adaptive Forest Management

MOTIVE D4.3. Descriptions and algorithms characterizing current and possible future silvicultural treatments in the MOTIVE Case Study areas

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Abstract:

In the MOTIVE case studies the decision space of potential management actions (required for decision making analyses in WP5) is calculated by simulating a set of alternative management schedules for a set of stands, within the framework of a set of management objectives and feasible climate scenarios. A protocol and template questionnaire (based on general knowledge on adaptive management) was provided to all case studies that allowed them to describe and select a set of alternative management schedules for each stand type in the case study. Some of the case studies that use specific simulation/decision making tools (e.g. based on stand-level simulation-optimization) or adopted a specific spatial/landscape level setup proposed alternative approaches for generating the alternative management regimes. The presented results will be used for simulating the required decision spaces by WP5 and reported to the MOTIVE database via the data client (WP6). The document provides representative information on the adaptive management regimes and approaches currently being considered in a wide range of European regions and forest types.

Keywords:

adaptive forest management regimes; climate change; forest goods, services and risks; simulation; decision space; optimization

Table of Contents

Executive summary

For each case study in the MOTIVE project the decision space of potential management actions will be developed by simulating a set of alternative management schedules for a set of stands (i.e. the smallest management unit). In all cases the simulation tools used are sensitive to climate change and integrate relevant risks (see D3.1). The simulated set needs to represent the feasible range of combinations between the considered goods, services and climatic impacts (e.g. increased fire risk or drought) in decision making.

A protocol and template questionnaire was provided to all case studies that allowed them to describe the proposed alternative management schedules. The main objective of the questionnaire was to identify (1) the current management regimes (business as usual management, BAUM) for each stand type (and relevant sites) in the case study and (2) possible adaptations (adaptive management, AM) that focus on a few general decision variables (e.g. species choice or timing and intensity for thinnings). The decision variables are varying across the adaptive management scenarios (AMs) and differ from the BAUM.

The value and range of the decision variables used to construct each AM may be based on general knowledge of adaptive management if no other sources are available. The aim of this approach (proposed in the delivered questionnaire and followed by most cases) is to select a relatively low number of management alternatives for each stand type while still maintaining a sufficient representation of the management objectives and climatic effects. However, some case studies that use specific simulation/decision making tools and/or adopted a specific spatial/landscape level setup have proposed alternative approaches for generating the AMs (e.g. stand-level optimization tools or using a prescription writer).

The results presented and discussed here will be used for simulating the decision spaces required for decision making analyses in WP5. The selected sets of management regimes will be characterized in the MOTIVE database via the meta data approach in the data client[1]. The document provides representative information on the adaptive management regimes and approaches currently being considered in a wide range of European regions and forest types.

[1] See *e.g.* WP6 document “Defining harmonized model output”

1. Introduction

Adaptive forest management can be defined as an iterative process through which knowledge acquired from past experiments and actions is used to modify management practices so as to better achieve management goals. In the case studies of the MOTIVE project, the acquisition of such knowledge is based on the development and application of advanced simulation tools (climate sensitive, integrating risks; see Deliverable3.1.), which in turn are based on empirical evidence of forest ecosystem dynamics and expert knowledge. Thus, selected management actions in decision making (WP5) will depend on projected future forest states (under potential changes of climate) and their impacts on relevant goods, services and risks.

In MOTIVE the case studies can be conceptualized as landscapes composed of stands, which represent the smallest management unit. A specific set of regionally relevant goods, services and risks is considered in each case. Some of the required attributes can be assessed at the stand level (e.g. timber, biomass) but others such as the risks of windthrow and wildfire or water yield require an assessment at the landscape level, which is more than the simple summation across management units or stands because spatial dependencies need to be taken into account. This has clear implications for to the simulation and decision making procedures that were adopted in the different cases (as can be seen in chapter 2.2.).

The basic exercise for generating knowledge for adaptive management, i.e. the decision space required for decision making, consists of simulating a set of alternative management schedules for each management unit. The simulated set needs to represent (at least to some extent) the feasible range of combinations between the goods and services considered and climatic impacts (e.g. increased fire risk or drought), i.e. “climatic effects(low, mean, high) x objectives (low, mean, high)”.

For describing the management regimes, a protocol and template was provided as a questionnaire to all case studies (**see Appendix A**; the summary presented below is based on the substantial materials returned and presented in **Appendix B**). The main objective of the questionnaire was to identify (1) the current management regimes (business as usual management, BAUM) for each stand type (and relevant sites) in the case study and (2) possible adaptations (adaptive management, AM) that focus on a few general decision variables (e.g. species choice, timing and intensity for thinnings, rotation length). The decision variables are varying across the AMs and differ from the BAUM.

The reports on BAUM and AMs received from the different cases are categorized, briefly summarized and discussed here.

2. Reports from the case studies

A detailed description of the main objectives, study area, and models used in each case study can be found in D3.1 of MOTIVE[2]. Here we will concentrate on the proposed BAUM and AM regimes and the approach followed for their determination.

The variation of decision variables for determining the AMs may be based on general knowledge on adaptive management (i.e., expert knowledge) if no other sources are available. If well addressed, this approach may allow selecting a relatively low number of management alternatives for each stand type while keeping a sufficient representation of the management objectives and climatic effects (which may help when using process-based tools that require considerable simulation effort). Several of the case studies followed this approach. However, a more systematic approach such as preliminary objective-specific simulation runs or stand-level optimization tools can also be used for efficiently representing the range of the selected management goals and climatic effects. This was in fact proposed by some of the case studies (see chapter 2.2.1.).

[2]Nabuurs, G.J., Trasobares, A., Eds., 2010. Motive D 3.1: Review of tools and recommendations for development.

The reports were consequently classified in two groups: (1) case studies following the approach proposed via the questionnaire in Appendix A; (2) case studies that have a specific setup or use specific simulation/decision making tools and thus decided to follow different approaches.

The detailed reports by case study can be found in Appendix B. Independent of the approach used for determining AM schedules, the selected sets of AM schedules (one for each stand x site type) for each case study will be reported to the MOTIVE database via the meta data approach in the data client.

2.1. Case studies that followed the suggested approach

Atlantic Veluwe case (2b)

This case presents a large variation in ***stand types***: even-aged *Fagus sylvatica* stands, even-aged *Quercus robur* and *Q. petraea* stands, uneven-aged *Betula pendula* - *Quercus spp*. stands, even-aged *Quercus rubra* stands, even-aged *Pseudotsuga menziesii* stands, even-aged *Pinus sylvestris* stands, even-aged *Larix kaempferi/decidua* stands, even-aged *Pinus nigra* stands, and even-aged *Picea abies* stands. Forest development is limited by the generally poor soils that have a high sand content and low water holding capacity. This is reflected in the forests ***management***, which ***focuses mainly on integrated practices*** with wood production as an additional secondary objective besides enhancing the ecological and cultural functions of the forest.The forest management that has been implemented in recent years and shall be applied in the entire case study area by around 2020 ***already integrates adaptive strategies*** for minimizing the effects of climate change (e.g., promoting the development of uneven-aged forests).

First simulation results suggest that the trends of climate change that were supplied by MOTIVE WP 2 may not create severe limitations to forest development in the case study region. In addition, the multi-purpose use of the forest and the integrated management practices that are already implemented restrict the identification of further adaptive strategies that may be improvements over the current BAUM. Nonetheless, alternative future management regimes have been developed. The considered ***objectives*** are timber production, carbon sequestration, biodiversity, and recreation. The ***climatic effects*** are: drought, fire risk, and storm risk. For each stand x site type a considerable amount of variation of adaptive alternatives is provided. Thus, a good representation of feasible "climatic effects (low, mean, high) x objectives (low, mean, high)" combinations is expected. ***Examples of adaptive management strategies***: i) RI by reducing the proportion of drought-intolerant species; ii) increasing AC by introducing more drought-tolerant provenances, e.g., increasing the proportion of native tree species such as *F. sylvatica* and diversifying the existing forest; iii) utilizing benefits (B) by focusing on wood production based on productive species such as *P. menziesii*, *Larix* spp. and *Quercus* spp.

Central Black forest case (3a1, LandClim)

The management regimes are grouped by management system: even-aged and uneven-aged. The higher elevation sites in the case study (stand/site type 1) are currently or have until recently been managed as even-aged Norway spruce plantations. The lower elevation sites (stand/site type 2) are managed as uneven-aged mixed forests. The BAUM for each of these stand/site types as well as 3 AM alternatives for each were defined. The range of feasible "climatic effects (low, mean, high) x objectives (low, mean, high)" is represented well. One of the interesting points in this case is the ***application of conversion regimes***: i) uneven-aged management systems will be applied to the currently even-aged sites; and ii) an oak-conversion regime (which consists of an even-aged conversion part and an uneven-aged target diameter harvesting part) will be applied to the currently uneven-aged sites. The main ***objectives*** are timber production and biodiversity. The ***climatic effects*** considered in the adaptations are drought, wind storms and insects mortality. ***Examples of adaptive strategies*** are: i) reducing the rotation length for minimizing the risk of drought and disturbance mortality (RI) in even-aged Norway spruce stands, ii) converting the currently drought threatened even-aged or uneven-aged Norway spruce forests to more drought- and disturbance-resistant mixed oak forest (RI), iii) promoting of a range of drought-adapted species and the conversion to an uneven-aged stand structure for increasing biodiversity and thus AC, and iv) exploiting the superior behavior of Douglas-fir in terms of growth rate and competitiveness under elevated temperatures (B).

Central Black forest case (3a2, stand level)

Six ***stand types*** have been chosen: mixed even-aged spruce (Norway spruce, beech, fir); mixed deciduous (mainly ash, maple, cherry, and chestnut); uneven-aged fir, spruce and beech stands; mixed extensively managed stands with locally adapted species; mixed and even-aged Douglas-fir stands (Douglas-fir and beech); beech mixed (with other broadleaves, other conifers) and even-aged stands. Site types within stand types were not differentiated since management is oriented at total height (such that timing is less important). Some relatively mild alternative management strategies have been chosen at the moment (to be taken as a starting point/draft). The main ***objectives*** are high quality timber production, single trees stability, carbon sequestration and structural biodiversity. The addressed ***climatic effects*** are drought and wind. ***Examples of adaptive strategies*** are reducing drought impact (RI) by regulating competition and rotation length, or increasing AC to drought by promoting a larger species pool in mixed stands.

Central Alpine case (3b1)

Eleven ***stand*** *x site* ***types*** (uneven-aged Norway spruce stands and uneven-aged Norway spruce dominated stands, along a broad range of sites) have been identified. This mountain area is focusing on ***uneven-aged management systems***. No management is applied at very ***steep sites*** while *cablecrane slit-cuts* (skyline tracks for regeneration; natural or planted; game management for protecting regeneration) are used at sites where management is feasible. The ***objectives*** are: protection against erosion, avalanches and rockfall; biodiversity; timber production; and provision of drinking water. The addressed ***climatic effects*** are intensified bark beetle disturbances and NPP change. For each stand x site type, two BAUM and three AMs are proposed. Thus, a good representation of feasible “climatic effects (low, mean, high)x objectives (low, mean, high)” combinations is expected. ***Examples of adaptivestrategies***against increasing *Ips typographus*disturbances include: i) decrease the proportion of Norway spruce by the introduction of European larch (RI), and the larger species set will increase AC; or ii) more frequent and larger management actions to reduce the share of over-mature stands (RI) and make better use of temperature-induced increases of tree growth rates (B).

Continental Bulgaria case (5a)

In this case the first phase of development is a regeneration cut, because most ***coppice forests***in the area are about at age 50 and according to the management plans it is usually desired to ***transform***them***into high forests***. Subsequently, they should be managed as high forests. The ***stand types*** are even-aged coppice sessile oak, even-aged coppice Hungarian oak, and even-aged coppice Turkey oak. The considered ***objectives*** are timber, carbon sequestration and biodiversity. The addressed ***climatic effects*** are drought and more frequent forest fires. For each stand x site type, two BAUM and two AMs are proposed. A reasonable representation of feasible “climatic effects (low, mean, high) x objectives (low, mean, high)” combinations is expected but perhaps some more adaptive management strategies for each stand type could be included. ***Examples of adaptive strategies*** *are*: i) reducing stand density/competition to reduce drought impact (RI); ii) promoting drought resistant species and increasing the size of the species pool (AC).

Continental Romania case (5b)

Stand types**:** Even-aged mixed Norway spruce and silver fir stands; even-aged mixed Norway spruce, silver fir and beech stands; and uneven-aged mixed Norway spruce, silver fir and beech stands. ***Objectives***: NPP; soil protection; biodiversity. ***Climatic effects*****:** drought and *Ips typographus* damage. The proposed AMs for addressing different climatic effects on the different stand types have been nicely evaluated (see diagram in Appendix B). As four AMs have been proposed for each stand x site type, the range of “climatic effects (low, mean, high) x objectives (low, mean, high)” combinations are probably well represented. ***Example of adaptive strategies***: In even-aged mixed Norway spruce stands affected by *moderate drought,* Silver fir and Norway spruce trees should adapt if stand density is regulated for RI and trees are adapted for B. Thinning intensity is reduced in order to decrease the level of evapotranspiration from soil (thinnings are suggested to extract the larger trees whose level of transpiration is higher). The maximum rotation age should be reduced to 110 y to avoid the development of a large number of standing dead trees that would increase fire risk.

2.2. Case studies using different approaches

The results summarized in the previous section illustrate the implementation of the suggested approach for determining the range of BAUM and possible AM regimes for each stand x site type in a given case study. The resulting set of management regimes (after being completed or improved in some cases) should enable the simulation of the decision space to be delivered to WP5 and WP6 for the analysis of decision making. However, some case studies are following alternative approaches for determining the set of alternative management regimes for each management unit (stand). For *Mediterranean Catalonia (4a)*, *Mediterranean Portugal (4b)* and *Atlantic Wales (2a)* cases, the reason for this is that these cases have available decision support tools that already contain a decision making/optimization module (see below). For the *S Boreal case*, the reason for an alternative approach is that the landscape level simulation approach features spatial inter-dependencies between stands for integrating wind risk, which thus requires a different treatment in the decision making. These alternative approaches are summarized below; the detailed feedback can be found in Appendix B.

2.2.1. Case studies using operations research methods

As mentioned in the Introduction, an alternative approach for determining a set of possible future adaptive managements in a given stand x site representing efficiently the feasible “climatic effects (low, mean, high) x objectives (low, mean, high)” combinations can be the use of **stand-level optimization** tools. For specific levels of a given objective (min., average, max.) and a given climate scenario, optimization techniques can be used to determine the optimal management schedule (and related set of decision variables, e.g. timing and intensity for thinnings, rotation length). The resulting AM schedules are heuristically optimal solutions of a stand-level problem. The simulation outcomes (decision space delivered to the MOTIVE database) related to these schedules can then be evaluated by the end user using his/her own preferences in the MOTIVE AFM toolbox (WPs 5 and 6).

The set of candidate management regimes for each stand x site in a given case study area may also be generated **using a prescription writer**, i.e. by programming a large number of deviations (as many as are technically feasible) from thedecision variables of the BAUM schedule (e.g. timing of thinning, rotation length, etc.), such that the range of all landscape-level objective variables is represented well. A large amount of alternative regimes is then used as the basis for decision making. This approach is typical in **landscape-level planning**, which focuses on determining the sequence of management schedules (a management schedule is selected for each stand) that optimizes a given objective function for the whole landscape.

Mediterranean Catalonia case (4a)

For the determination of adaptive management strategies in even-aged *P. sylvestris* stands in Catalonia, case study 4a presents a first attempt to optimize forest stand management in a Mediterranean context in the light of various changing climatic scenarios, considering different economic and ecological management objectives. To do so, a***new forest management decision support system*** was developed ***based on*** the existing process based model***GOTILWA+*** (Growth Of Trees Is Limited by WAter). This model was

expanded into a decision support system ***by linking it to a Particle Swarm optimization algorithm*** and a new ***interface that allows selecting*** among a set of ***management objectives, decision variables, climate scenarios and economic parameters*** in order to optimise the management of a given forest stand (species, density, site conditions, etc.).

The aim of this study is to optimize the management of *P. sylvestris* stands in the north-east of Spain (Catalonia) under two different climate scenarios and four different management objectives: (1) timber profitability (land expectation value), (2) biomass production (or carbon sequestered), (3) stand-level water use efficiency and (4) fire risk-adjusted timber profitability. For illustrative figures and the type of expected results, cf. Appendix B. The results of these optimization problemswill form the set of possible AMs for each stand x site typethat is considered in the case study area.

N Boreal case (1a)

The stand types are even-aged *P. sylvestris* stands, even-aged *Picea abies* stands and even-aged *Betula pendula* stands. The main ***objectives*** are timber production, carbon sequestration and maintenance of biodiversity in forests. The addressed ***climatic effects*** are NPP changes and drought (Norway spruce).The Finn For process-based model has been used to produce a link from a given climate change scenario to a stand-level simulation-optimization tool (with empirical growth model) to be used for forest planning (individual tree diameter and height increment; see ongoing D3.2/3.3).

For each stand x site type, 2 BAUM/AM regimes have been reported (the BAUM and AMs are expected to be nearly identical, as only a few decision variables will change) according to the suggested template (see Appendix B). The proposed schedules (based on Finnish thinning rules) should automatically adapt to changes in NPP/climate (the timing for thinnings and clear-cut will change). Some **examples of adaptive strategies** are as follows: i) in Scots pine stands Adaptive Capacity (AC) is addressed by using improved seeding material (this should also improve timber quality); ii) In Norway spruce stands, the focus is on species and genotype choice for Reducing the Impacts (RI) and AC, i.e., planting of slightly more southern genotypes of Norway spruce (drought resistance), or of Scots pine on medium fertile sites with low soil water holding capacity; iii) Betula pendula is a winner under changing climate because of its high adaptive capacity (high regeneration success and growth).

For generating the AMs for each stand x site type, a stand-level simulation-optimization tool will be used varying the objective function across the main objectives, for a given climate scenario. Because the different alternatives for a given stand x site are likely to be quite similar, the change of species will be considered in some cases (i.e. on soils with poor water/nutrient availability).As a matter of fact, this has been addressed already in some of the initially presented BAUM/AM schedules (see paragraph above). Case study 1a will also run/solve landscape level planning problems using the MONSU decision support system.

Mediterranean Portugal case (4b)

In Portugal, stand-level and landscape-level planning/optimisation tools are available. Fire risk is a core focus for the case study.Methods and tools are developed to 1) generate the decision space (feasible set of AMs), 2) compare AM according to a set of decision-maker goals and 3) select the “best” AM or the “best” combination of AMs in the case of stand and landscape-level problems, respectively, under each climaticscenario (see Figure 1 in Appendix B).

As in case 1a, the idea here is also to link a process-based model with an empirical one to allow for modifications if a climate change scenario is considered (see D3.1. and D3.2.). The generation of AMs for each stand x site type will be based on stand- (e.g. stochastic dynamic programming, SDP) or landscape-level optimization approaches (more details in Appendix B).

The group is working on approaches to use SDP to supply stand-level state dependent optimal management schedules for a given climate change scenario. Therefore, in a similar way as in cases 4a and 1a, a given set (for each stand x site type) of AM optimal management schedules representing the feasible combinations of objectives and climatic scenarios will be determined (and reported to the MOTIVE database).The BAUM managements for the *Pinus pinaster*, *Quercus suber* and *Eucalyptus globulus* stands in the case study can be found in Appendix B.

2.2.2. Case studies dealing with spatial inter-dependencies

S Boreal case (1b)

This case study is specifically addressing spatial interdependencies in the calculation of ecosystem goods and services. ***The AMs will depend on the locationof stands***, and therefore the approach originally proposed for defining BAUM and AM regimes (Appendix A) does not apply.

For the Kronoberg case study, the FTM model is used to project the state of the forest within a landscape until the year 2100 under the A1B scenario and under no climate change. A BAUM and a wind damage risk adapted management regime (AM) are considered for each stand type. The growth engine in FTM accounts for climate change by adjusting site index. ***Part of the AM depends on location***. These simulations will be made at a time step of 5 yrs. The WINDA-GALES model calculates the annual probability of wind damage for a specific state of the forest. To calculate the probability of wind damage, climate data for a 30-yrperiod are used. The WINDA-GALES model is run on the states of the forest for specific years and for a corresponding 30-yr wind climate. The model is spatially explicit.For no climate change effect, the probability of wind damage is calculated for individual years and aggregated to cover 30-yr periods centered on the years 2015, 2030 and 2085 using wind data for the reference period.For the A1B scenario the corresponding calculations using BAUM and AM will be made separately. A1B will affect the growth of the forest starting in year 2001. In the case of AM, this will be applied starting in year 2001 in one simulation and in year 2031 in a second simulation (BAUM until 2030).

To date, the AM strategy without climate change has been devised with the assistance of the Kronoberg stakeholder panel.This AM strategy is continuously adjusted to a changing climate when used in a climate change situation (the applied stand management programme is sensitive to changes in SI/climate). The submitted BAUMs and AMs depict what happens if they are applied without climate change. The addressed ***stand types*** are: even-aged spruce pure stands, even-aged mixed coniferous stands, even-aged mixed stands (pine, spruce, birch, oak and other broadleaves), and even-aged pure birch stands. The ***main objective*** is ***timber production*** and the addressed climatic effect is ***increasing risk of wind damage***. ***Example of adaptive management strategy***: for a pure and even-aged spruce stand of average to good productivity in southern Sweden, the main objective is timber production. Rotation period is shortened and the last thinning carried out before a H_{dom} of 21 m is reached, so as to reduce the risk of wind damage. On wind-exposed sites, a species change to birch is performed at the first upcoming regeneration.

The Kronoberg case study would prefer not to deliver stand level data to the MOTIVE database as the whole model is essentially spatial in nature, and the AFM or BAUM cannot be considered for a stand independent of the spatial context.The case study offers instead a visual example in a set of maps and coupled with options to evaluate the outcomes of the 2 (BAUM, AFM) x 2 (current climate, A1B) simulations.

Atlantic Wales case (2a)

BAUM regimes represent current Forest Management Alternatives (FMAs) appropriate to the Clocaenog and Gwydr forest areas in the WALES case study. BAUM regimes corresponding to the ***stand types*** in this case study (Unmanaged Oak Nature Reserve; Continuous Cover Forestry (CCF) Sitka spruce YC 14; CCF

Birch YC 4; Intensive even-aged management Sitka spruce YC 14; Intensive even-aged management Douglas fir) can be found in Appendix B. The main ***objectives*** are: timber production, carbon sequestration, biodiversity, and recreation.

The determination of AMs will be based around changes in the proportion and structure of FMAs as well as diversification of species that are achievable, which would be expected to improve resilience to climate change (AC), and are compatible with the current policy for climate change adaptation. **Current FMAs and species will be mapped spatially** at the sub-compartment (i.e. forest stand) level, and potential AM alternatives will be selected for each using the 'MOTIVE8-Wales' suite of models. Species suitability and potential yield in future climate scenarios will be examined for each sub-compartment, and decision trees for conversion of FMAs using soil and climate data will be applied. The choice of thinning regime, stand rotation or transformation to CCF will be assessed and constrained in relation to wind risk. The range of potential regimes (FMA deviations / species choice) and their respective impact on social, economic and environmental sustainability indicators will be used as the basis for AM decisions by different MOTIVE manager types.

As described above, in this case the determination of AMs is also related to the spatial context in each stand (a decision making process using decision trees is also involved in the process). Therefore, results/decision spaces according to different climate scenarios and objectives may be delivered as a set of maps. The reporting (description) of the final set of BAUM and AMs to the MOTIVE database will be harmonized with this approach.

Appendix A: Questionnaire sent to the case studies

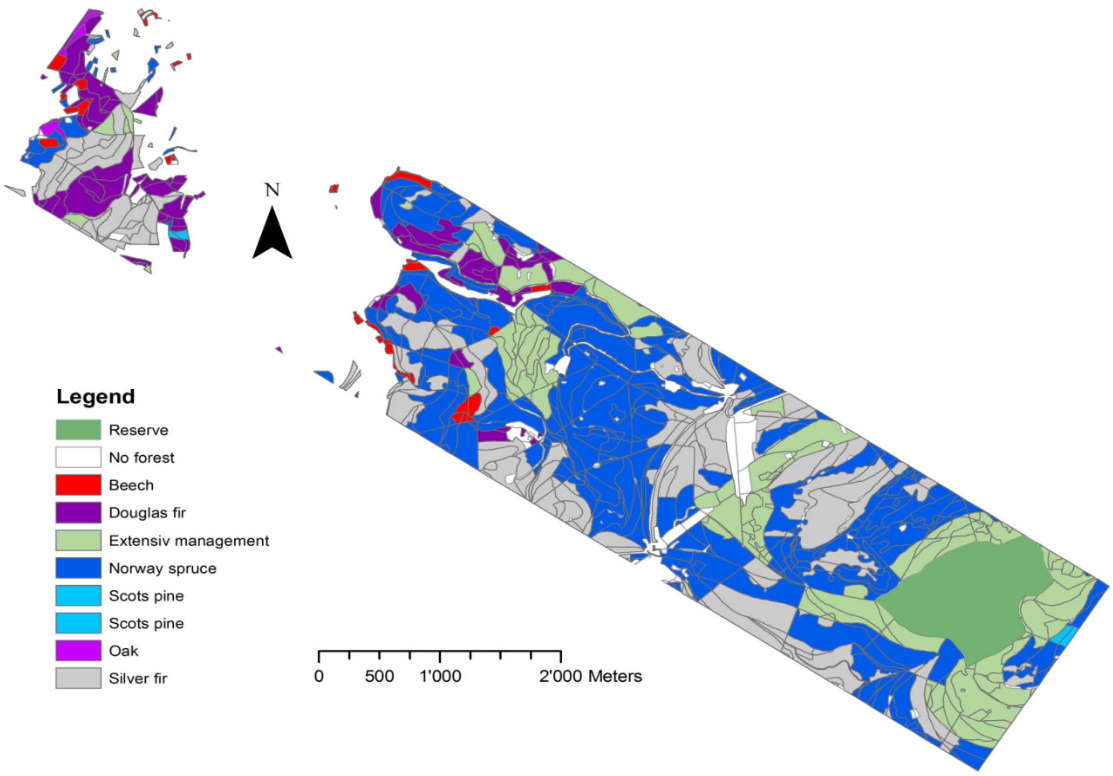
The current (business as usual management, BAUM) and possible adaptive management (AM) regimes in each case study will be the basis for simulating the decision space to be delivered to WP5 and WP6 (MOTIVE database). The decision space will be based on

- **BAUM** in the case study regions **defined**& simulated **for (n) (stand x site) types** under (i) climates
- (k) **AM** schedules in case study regions **defined**& simulated **for (n) (stand x site) types** under (i) climates

The objective is to select a set of management regimes for the main stand type x site combinations in the case study, bearing in mind **i)** a **good representation of the likely range** of management **objectives** (goods, services and risks) and **ii)** climate change effects.

The steps of this exercise are as follows[3]:

1. *Identify the main stand x site types in the case study*



Stand type classification in the black forest case study.

- Distinguish different site types (if more than one exists) for each stand type

Examples:

- Even-aged beech pure stands, site type 1 (soil type: xxx, nutrients: medium, water: high)
- sitetype 2 (…)

[3] An example using beech stands in Switzerland is provided below

- Even-aged mixed beech/Norway spruce stands, site type 1 (…)
- Uneven-aged beech/Norway spruce/fir stands, site type 1 (…)

etc.

2. *Identify BAUM regimes for each stand x site type*

- BAUM regimes can be identified according to forest plans in the region, existing management models, policy regulations, and/or interactions with forest managers (stakeholder dialogue)

3. *Designing possible AM regimes for each stand x site type*

3.1 Decide which climate change effect (Net primary production (NPP) changes, drought, fire, insects, etc.) is addressed by the AM regime, i.e. what the AM is designed to counteract better or benefit more from than the BAUM.

- Bear in mind the range of the management objectives we are considering (e.g. biomass production, biodiversity..), i.e. consider:
  - Climatic effects (low, mean, high) x objectives (low, mean, high)

3.2 Apply general approaches for adaptive management

a) utilize the potential benefits arising from a changing climate (B)
b) reduce potential negative impacts arising from a changing climate (RI)
c) increase adaptive capacity to prepare for uncertain future climate (AC)

3.3 When designing AMs, focus on a few general decision variables[4], which are varied across AM's and differ from the BAUM, e.g.:

a) Species composition (applies equally to genotypes):

Change species composition (RI; B)

Enrich species pool (AC)

b) Thinning regime:

Change type (RI, B, AC)

Change intensity (RI, B, AC)

Change interval (RI, B, AC)

c) Regeneration method (RI, B, AC):

Clear cut

Change timing (rotation age)

Shelterwood, irregular shelterwood, (…)

Regeneration cuts: change intensity or interval (i.e. regeneration period; period between first shelterwood cut and clearing the residual stand)

Final cut (change timing – rotation age)

Planting, natural regeneration

[4] Based on the literature such as COST ECHOES WG2

d) Uneven-aged management only:

Change interval (RI, B, AC)

Change harvest intensity in each diameter class (RI, B, AC)

Example using beech stands in Switzerland

Stand x site type 1: Even-aged beech pure stands, site 1 (soil type: xxx, nutrients: average, water: average)

Case study	Switzerland *(this is just a template, not a MOTIVE case study)*	
Stand x site type	- Even-aged beech pure stands - Soil type: xxx ; Nutrients[5] (poor, average, high): average ; Water[1](low, average, high): average	
Management alternative	**No.: 1** **BAUM/AM:** BAUM **System**: Even-aged shelter **Regeneration:** natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** heavy **Entry interval:** 10y **Addressed climate change effect**: N/A **Adaptation strategy (B, RI, AC)**: N/A **Expected level for addressed objectives (low, average, high)**: timber production (high); carbon sequestration (average), biodiversity (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	ca. 15000-20000 trees/ha, H_{dom} = 9 m (dominant height) at 20 yr
Young	Tending	D_{dom} (dominant diameter) >= 10 cm : tending to 3750 stems/ha
Medium	Thinning 1	$D_{dom} \geq 20$ cm: Thinning to 1875 stems/ha
	Thinning 2	$D_{dom} \geq 25$ cm: Thinning to 840 stems/ha
	Thinning 3	$D_{dom} \geq 35$ cm: Thinning to 380 stems/ha
Adult	Regeneration cut	$D_{dom} \geq 40$ cm: Thinning to 120 stems/ha
	Final cut	Around 120 trees at Ddom>= 45 cm Maximum rotation age: 120
Short description: BAUM management schedule for a pure and even-aged beech stand of average to good productivity in Switzerland(Kollinesubmontan elevation stage). The main objective is timber production (thinnings from above in favor to target trees of high quality). Carbon sequestration and biodiversity also considered.		

[5]"Nutrients" refers to (content x availability); "Water" refers to (holding capacity x availability)

- Note that in the AM regimes shown next the modified decision variables and values (with respect to the BAUM) are highlighted in red

Case study	Switzerland *(this is just a template, not a MOTIVE case study)*	
Stand x site type	- Even-aged beech pure stands - Soil type: xxx ; Nutrients (poor, average, high): average ; Water (low, average, high): average	
Management alternative	**Nr: 2** **BAUM/ AM:** AM **System**: Even-aged shelter **Regeneration:** natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** heavy **Entry interval:** 10y **Addressed climate change effect**: drought **Adaptation strategy (B, RI, AC)**: RI, AC **Expected level for addressed objectives (low, average, high)**: timber production (average); carbon sequestration (average), biodiversity (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Around 15000-20000 trees/ha and 9 m Hdom (dominant height) at 20 years
Young	Tending	Ddom (dominant diameter) >= 10 cm : tending to 3750 stems/ha
Medium	Thinning 1	Ddom>= 15 cm : Thinning to 1875 stems/ha
	Thinning 2	Ddom>= 20 cm : Thinning to 840 stems/ha
	Thinning 3	Not applied.
Adult	Regeneration cut	Ddom>= 25 cm : Thinning to 120 stems/ha
	Final cut	Around 120 trees at Ddom>= 30 cm Maximum rotation age: 130
Short description: Drought is expected to affect beech stands in the coming years. Beech trees should adapt to these conditions if stand density (competition for water) is regulated for RI and increase the AC of trees in the stand.		

Case study	Switzerland *(this is just a template, not a MOTIVE case study)*	
Stand x site type	- Even-aged beech pure stands - Soil type: xxx ; Nutrients (poor, average, high): average ; Water (low, average, high): average	
Management alternative	**Nr: 3** **BAU/ AM:** AM **System**: Even-aged shelter **Regeneration:** natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** heavy **Entry interval:** 10y **Addressed climate change effect**: moderatedrought **Adaptation strategy (B, RI, AC)**: RI **Expected level for addressed objectives (low, average, high)**: timber production (low-average); carbon sequestration (high), biodiversity (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Around 15000-20000 trees/ha and 9 m Hdom (dominant height) at 20 years
Young	Tending	Natural tending
Medium	Thinning 1	Ddom>= 20 cm : Thinning to 1500 stems/ha
	Thinning 2	Not applied
	Thinning 3	Not applied
Adult	Regeneration cut	Thinning 120 target trees at Ddom>= 50 cm for timber
	Final cut	Maximum rotation age: 170 ; remove remaining overstory
Short description: Moderate drought may affect the stand in the coming years. The management regime is modified for RI of drought but also in order to increase carbon sequestration and biodiversity. Timber production of enough quality may be reduced due to the longer rotation (red center) and greater size of trees (woodpecker likes trees > 45 cm). Biodiversity may increase with the presence of larger and older trees.		

- Other AM alternatives for the (stand x site) type should be added for representing the likely range of management objectives and climate change effects. With 3 main objectives and 1-2 climate change effects one may easily need 3-4 AM regimes..

Stand x site type 2: Uneven-aged beech, Norway spruce and silver fir stands, site 1 (soil type: xxx, nutrients: average, water: average)

Case study	Switzerland *(this is just a template, not a MOTIVE case study)*			
Stand x site type	- Uneven-aged beech, Norway spruce and fir stands - Soil type: xxx ; Nutrients (poor, average, high): average ; Water (low, average, high): average			
Management alternative	**Nr: 1** **BAUM/ AM:** BAUM **System**: Uneven-aged **Selection cuttings intensity (weak, average, heavy):** heavy **Addressed climate change effect**: N/A **Adaptation strategy (B, RI, AC)**: N/A **Expected level for addressed objectives (low, average, high)**: timber production (high); carbon sequestration (average), biodiversity (low-average)			
Cutting cycle	10 years			
Threshold basal area for management	>= 35 m^2/ha ; assuming inverse J shaped (or close to it) diameter distribution of the initial stand			
Diameter class	**10-25 cm**	**25-40 cm**	**40-55 cm**	**> 55 cm**
Harvest intensity (HI), in trees %	Beech = 50 N. spruce = 5 Silver fir = 5	Beech = 100 N. spruce = 20 Silver fir = 20	Beech = 0 N. spruce = 40 Silver fir = 30	Beech = 0 N. spruce = 100 Silver fir = 100
Short description:BAU management regime for uneven-aged beech, Norway spruce and fir stands of average to good sites in Switzerland (nowadays mainly in theuntermontan and obermontan elevation stages). High timber production is expected. Carbon sequestration and biodiversity also considered.				

Case study	Switzerland *(this is just a template, not a MOTIVE case study)*			
Stand x site type	- Uneven-aged beech, Norway spruce and fir stands - Soil type: xxx ; Nutrients (poor, average, high): average ; Water (low, average, high): average			
Management alternative	**Nr: 2** **BAU/ AM:** BAUM **System**: Uneven-aged **Selection cuttings intensity (weak, average, heavy):** heavy **Addressed climate change effect**: NPP_change, drought **Adaptation strategy (B, RI, AC)**: B, RI, AC ; **Expected level for addressed objectives (low, average, high)**: timber production (average); carbon sequestration (low-average), biodiversity (low-average)			
Cuttingcycle	10 years			
Threshold basal area for allowing management	28 m^2/ha ; assuming inverse J shaped (or close to it) diameter distribution of the initial stand			
Diameter class	**10-25 cm**	**25-40 cm**	**40-55 cm**	**> 55 cm**
Harvest intensity (HI), in tree %	Beech = 10 N. spruce = 70 Silver fir = 20	Beech = 20 N. spruce = 100 Silver fir = 30	Beech = 30 N. spruce = 0 Silver fir = 30	Beech = 100 N. spruce = 0 Silver fir = 100
Short description: An increase in aridity may create drought conditions for Norway spruce (root system does not reach deep soil layers), moderate drought for fir and NPP_change (increase) for beech. In order to adapt the mixture beech/fir is promoted. Harvest intensities and management interval are modified aiming B+RI+AC. This alternative is expected to lead to lower timber production and carbon sequestration than BAUM.				

Other AM alternatives for the (stand x site) type ..

APPENDIX B: Reports provided by the case studies

Atlantic Veluwe case (2b)

Current and possible future management regimes in the MOTIVE case study Atlantic Veluwe

The case study area is a forest area of approximately 10,000 ha and is located in the south east of the Veluwe in central Netherlands. The extensive forests in the study area consist mainly of Scots pine (*Pinus sylvestris* L.) stands that were planted in the 19th and 20th century. The main endemic tree species that occur in the study area are birch (*Betula pubescens* Roth and *B. pendula* Roth.), oak (*Quercus robur* L. and *Q. petraea* L.) and beech (*Fagus sylvatica* L.). Further species, including introduced species, that are present comprise Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco), Norway spruce (*Picea abies* L.), larch (*Larix decidua* Mill. and *L. kaempferi* (Lamb.) Carr.), and Red Oak (*Q. rubra* L.). Heathlands form a further important vegetation type in the study area.

Forest development is limited by the generally poor soils that have a high sand content and low water holding capacity. This is reflected in the forests management which focuses mainly on integrated management with wood production only as additional objective besides enhancing the ecological and cultural functions of the forest. This is also stimulated by the provincial natural resources management regulations that determine subsidies for land owners based on land use. Of the 7 land owners in the case study, 2 follow largely a no intervention policy, 3 perform integrated management with minimal harvesting to promote native deciduous tree species, and 2 perform integrated management and aim also for wood production as a main management objective (Table 1). All land owners have to maintain the dense network of pathways for safety and access for recreation and also for disaster management.

Table 1. Current management by owner and property in the Veluwe case study area.

ID, Owner (property)	Current Management (BAUM)
#1 Geldersch Landschap (Loenermark)	Integrated – promote native tree species (incl. maintenance of heath lands)
#2 Gemeente Rheden	Integrated – promote native tree species (incl. maintenance of heath lands)
#3 Middachten	Integrated – wood production
#4 Natuurmonumenten (Veluwezoom)	No intervention (incl. no intervention on heath lands)
#5 Private (Landgoed Rosendael)	Integrated – wood production
#6 Staatsbosbeheer (Rozendaalse Bos, Northern & Central part)	No intervention
#7 Staatsbosbeheer (Rozendaalse Bos, Southern part)	Integrated – promote native tree species
#8 Twickel (Hof te Dieren)	Integrated – promote native tree species
#9 Twickel (Schaddeveld)	Integrated – wood production

The forest management that has been implemented in recent years and shall be applied in the entire case study area by around 2020 already integrates adaptive strategies for minimizing the effects of climate change. For example, the relatively homogeneous forest structure that is the result of the plantations is being diversified through small-scale interventions that promote the development of an uneven-aged forest and increase the proportion of endemic tree species. The possible trends of climate change that have been supplied by MOTIVE WP 2 project only minor limitations to forest development compared to current conditions and compared to other climate change scenarios such as the KMNI W+. Exploratory simulations of future forest development for the 3 MOTIVE climate change scenarios are in support of this.

The multi-purpose use of the forest and the integrated management practices that are already implemented will restrict the identification of further adaptive strategies. In the light of the for MOTIVE relevant climate change projections, it will be challenging to communicate to the land owners the need for a change in management strategies. For the purpose of this report, business as usual management is described as the management that is applied currently in the majority of the forests in the study area (Table 1). Three alternative future management regimes are identified (Table 2).

Table 2. Adaptive management regimes and associated focus in general approach by owner and property in the Veluwe case study area (see site and stand specific tables for details).

ID	AM_{RI}	AM_{AC}	AM_B
1	limited conversion of non-native tree species; maintain heath [RI]	full conversion of non-native tree species; maintain heath [AC]	wood production (incl. on heath lands); no conversion [B]
2	limited conversion of non-native tree species; maintain heath [RI]	full conversion of non-native tree species; maintain heath [AC]	wood production (incl. on heath lands); no conversion [B]
3	low wood production; limited conversion [RI]	wood production; full conversion of non-native tree species [AC]	increased wood production; no conversion [B]
4	limited conversion of non-native tree species; allow controlled succession on heath land [RI]	no intervention in forest and on heath land [AC]	wood production (incl. on heath lands); no conversion [B]
5	low wood production; limited conversion [RI]	wood production; full conversion of non-native tree species [AC]	increased wood production; no conversion [B]
6	limited conversion of non-native tree species; maintain heath [RI]	no intervention in forest; maintain heath [AC]	wood production (incl. on heath lands); no conversion [B]
7	limited conversion of non-native tree species; maintain heath [RI]	full conversion of non-native tree species; maintain heath [AC]	wood production (incl. on heath lands); no conversion [B]
8	limited conversion of non-native tree species; maintain heath [RI]	full conversion of non-native tree species; maintain heath [AC]	wood production (incl. on heath lands); no conversion [B]
9	low wood production; limited conversion [RI]	wood production; full conversion of non-native tree species [AC]	increased wood production; no conversion [B]

These are based on the management objectives set for 2020 for the forests within a property belonging to an owner. Additionally, the alternative future management regimes represent concerns over a) the perceived need for adaptation in response to the degree of climate change, and b) the general approach to adaptive management (i.e., utilizing potential benefits [B], reducing potential adverse impacts [RI], increasing adaptive capacity [AC]). The general approach to adaptive management is the main rational behind the management alternatives; each alternative focuses on one approach. For example, a strategy in the context of the integrated management that is implemented in the study area would focus on:

i) reducing impacts by reducing the proportion of drought-intolerant species, e.g., converting P. *abies* stands, not promoting F. *sylvatica*, but not aiming for forest diversification and increasing the proportion of native tree species.

ii) increasing the adaptive capacity by introducing more drought-tolerant provenances, e.g., increasing the proportion of native tree species such as F. *sylvatica* and diversifying the exiting forest;

iii) utilizing benefits by focusing on wood production based on productive species such as P. *menziesii*, *Larix* spp and *Quercus* spp.

Stand x site type 1: Even-aged Fagus sylvatica stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-aged Fagus sylvatica - Soil type: sandy; Nutrients[6] (poor, average, high): poor ; Water[1](low, average, high): low	
Management alternative	**No.: 1 (integrated Management – low intensity)** **BAUM/AM: BAUM** **System**: Regeneration cut **Regeneration:** Natural **Thinning type (below, above):** NA **Thinning intensity (weak, average, heavy):** None **Entry interval:** unspecified **Addressed climate change effect**: NA **Adaptation strategy (B, RI, AC)**: NA **Expected level for addressed objectives (low, average, high)**:timber production (low); carbon sequestration (low), biodiversity (average), increasing drought resistance (average), reducing fire risk (average), reducing storm risk (average), increasing recreational value (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- Promote regeneration of endemic deciduous species, part. F. sylvatica, Quercus petraea and Q. robur and also Betula pendula - Encourage development of uneven-aged forest structure and tree species diversity - Due to the high browsing pressure, Q. robur saplings > 1.5m need to be planted
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	None
	Thinning 2	None
Adult	Regeneration cut (if shelterwood system)	Only in mast years; remove weak individuals; gap size variable, max. 0.4 ha; depends on focus species (for F. sylvatica regeneration: max. 0.07 ha; for Quercus regeneration 0.15 – 0.4 ha)
	Final cut (if shelterwood system)	None
Short description: low-intensity, integrated management to improve ecological and recreation function; applied on ca. 1/3 of the forested area in the region; practices are similar across stand types; no commercial use considered.		

[6] "Nutrients" refers to (content x availability); "Water" refers to (holding capacity x availability)

Stand x site type 1: Even-aged *Fagus sylvatica* stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-aged Fagus sylvatica - Soil type: sandy; Nutrients (poor, average, high): poor ; Water(low, average, high): low	
Management alternative	**No.: 2 (integrated Management – Wood production)** **BAUM/AM: BAUM** **System**: Future tree selection **Regeneration:**Natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:**variable **Addressed climate change effect**: NA **Adaptation strategy (B, RI, AC)**: NA **Expected level for addressed objectives (low, average, high)**:timber production (average); carbon sequestration (average), biodiversity (average), increasing drought resistance (average), reducing fire risk (average), reducing storm risk (average), increasing recreational value (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- Promote regeneration of endemic deciduous species, part. F. sylvatica, Quercus petraea and Q. robur and also Betula pendula - Encourage development of uneven-aged forest structure and tree species diversity - Due to the high browsing pressure, Q. robur saplings > 1.5m need to be planted
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	Future tree selection, first entry after ca. 25 years, select 60-80 individuals/ha, preferably native deciduous species, and remove competitors
	Thinning 2	- every 5 years thinning of max. 25% of stand to maintain environment for selected future trees - Ca. 15-20 years after first entry; remove ca. 50% of future trees selected in Thinning 1
Adult	Regeneration cut (if shelterwood system)	None
	Final cut (if shelterwood system)	Remove remaining future trees once they have reached age of ca. 100 years (deciduous species) or ca. 80 years (coniferous species)
Short description: mainly in stands on the somewhat richer sandy loams in the south of the study area		

Stand x site type 1: Even-aged Fagus sylvatica stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-aged Fagus sylvatica - Soil type: sandy; Nutrients (poor, average, high): poor ; Water(low, average, high): low	
Management alternative	**No.: 3 (multifunctional, limited conversion)** **BAUM/AM: AM** **System**: Regeneration cut **Regeneration:**Natural **Thinning type (below, above):** NA **Thinning intensity (weak, average, heavy):** None **Entry interval:**unspecified **Addressed climate change effect**: Drought **Adaptation strategy (B, RI, AC)**: RI **Expected level for addressed objectives (low, average, high):)**:timber production (low); carbon sequestration (average), biodiversity (high), increasing drought resistance (high), reducing fire risk (average), reducing storm risk (average), increasing recreational value (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- Promote regeneration of endemic deciduous species of high tolerance to drought, part. Quercus petraea and Q. robur and also Betula pendula - Encourage development of uneven-aged forest structure - Due to the high browsing pressure, Q. robur saplings > 1.5m need to be planted
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	None
	Thinning 2	None
Adult	Regeneration cut (if shelterwood system)	Natural regeneration: only in mast years; Remove weak individuals; Gap size for Quercus regeneration 0.15 – 0.4 ha; Planting as needed
	Final cut (if shelterwood system)	None
Short description: low-intensity management aiming at reducing risks from droughts		

Stand x site type 1: Even-aged Fagus sylvatica stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-aged Fagus sylvatica - Soil type: sandy; Nutrients (poor, average, high): poor ; Water(low, average, high): low	
Management alternative	**No.: 4 (multifunctional, full conversion)** **BAUM/AM: AM** **System**: Regeneration cut **Regeneration:**Natural **Thinning type (below, above):** NA **Thinning intensity (weak, average, heavy):** None **Entry interval:**unspecified **Addressed climate change effect**: Drought **Adaptation strategy (B, RI, AC)**: AC **Expected level for addressed objectives (low, average, high):)**:timber production (low); carbon sequestration (average), biodiversity (average), increasing drought resistance (high), reducing fire risk (average), reducing storm risk (average), increasing recreational value (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- Introduce more drought resistant F. sylvatica provenances by underplanting - Encourage development of uneven-aged forest structure and tree species diversity
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	None
	Thinning 2	None
Adult	Regeneration cut (if shelterwood system)	Natural regeneration: only in mast years; Remove weak individuals; Gap size for F. sylvatica regeneration: max. 0.07 ha; Planting as needed
	Final cut (if shelterwood system)	None
	Clear cut..	None
Short description: introduction of new drought-tolerant Fagus provenances; low-intensity management to improve ecological and recreation function, no commercial use;		

Stand x site type 1: Even-aged *Fagus sylvatica* stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-aged Fagus sylvatica - Soil type: sandy; Nutrients (poor, average, high): poor ; Water(low, average, high): low	
Management alternative	**No.: 5 (multifunctional with wood production)** **BAUM/AM: AM** **System**: Future tree selection **Regeneration:**Natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:**variable **Addressed climate change effect**: Drought **Adaptation strategy (B, RI, AC)**: B **Expected level for addressed objectives (low, average, high)**:**)**:timber production (average); carbon sequestration (average), biodiversity (average), increasing drought resistance (average), reducing fire risk (average), reducing storm risk (average), increasing recreational value (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- Regeneration of endemic deciduous species, part. F. sylvatica, Quercus petraea and Q. robur and also Betula pendula - Encourage development of uneven-aged forest structure and tree species diversity - Due to the high browsing pressure, Q. robur saplings > 1.5m need to be planted
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	Future tree selection, first entry after ca. 25 years, select 60-80 individuals/ha, preferably native deciduous species, and remove competitors
	Thinning 2	- every 5 years thinning of max. 25% of stand to maintain environment for selected future trees - Ca. 15-20 years after first entry; remove ca. 50% of future trees selected in Thinning 1
Adult	Regeneration cut (if shelterwood system)	None
	Final cut (if shelterwood system)	Remove remaining future trees once they have reached age of ca. 100 years (deciduous species) or ca. 80 years (coniferous species)
	Clear cut..	None
Short description: utilize potential benefits of climate change by harvesting at moderate intensity; no efforts to convert to more productive species		

Stand x site type 1: Even-aged Fagus sylvatica stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-aged Fagus sylvatica - Soil type: sandy; Nutrients (poor, average, high): poor ; Water(low, average, high): low	
Management alternative	**No.: 6 (low wood production, limited conversion)** **BAUM/AM: AM** **System**: Future tree selection **Regeneration:**Natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** low **Entry interval:**variable **Addressed climate change effect**: Drought **Adaptation strategy (B, RI, AC)**: RI **Expected level for addressed objectives (low, average, high):)**:timber production (low); carbon sequestration (average), biodiversity (average), increasing drought resistance (high), reducing fire risk (average), reducing storm risk (average), increasing recreational value (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- Promote regeneration of endemic deciduous species of high tolerance to drought, part. Quercus petraea and Q. robur and also Betula pendula - Encourage development of uneven-aged forest structure - Due to the high browsing pressure, Q. robur saplings > 1.5m need to be planted
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	Future tree selection, first entry after ca. 25 years, select 40-60 individuals/ha
	Thinning 2	- every 5 years thinning of ca. 25% of stand to maintain environment for selected future trees - Ca. 15-20 years after first entry; remove ca. 50% of future trees selected in Thinning 1
Adult	Regeneration cut (if shelterwood system)	Gap size for Quercus regeneration 0.15 – 0.4 ha; Planting as needed
	Final cut (if shelterwood system)	Remove remaining future trees once they have reached age of ca. 100 years (deciduous species) or ca. 80 years (coniferous species)
	Clear cut..	None
Short description: production oriented alternative to low intensity management with focus on reducing risks from climate change		

Stand x site type 1: Even-aged Fagus sylvatica stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-aged Fagus sylvatica - Soil type: sandy; Nutrients (poor, average, high): poor ; Water(low, average, high): low	
Management alternative	**No.: 7 (wood production and conversion)** **BAUM/AM: AM** **System**: Future tree selection **Regeneration:**Natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:**variable **Addressed climate change effect**: Drought **Adaptation strategy (B, RI, AC)**: AC **Expected level for addressed objectives (low, average, high)**:):timber production (average); carbon sequestration (average), biodiversity (average), increasing drought resistance (high), reducing fire risk (average), reducing storm risk (average), increasing recreational value (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- Introduce more drought resistant F. sylvatica provenances by underplanting - Encourage development of uneven-aged forest structure and tree species diversity
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	Future tree selection, first entry after ca. 30 years, select 60-80 individuals/ha, preferably native deciduous species, and remove competitors
	Thinning 2	- every 5 years thinning of ca. 25% of stand to maintain environment for selected future trees - Ca. 15-20 years after first entry; remove ca. 50% of future trees selected in Thinning 1
Adult	Regeneration cut (if shelterwood system)	Gap size for F. sylvatica regeneration: max. 0.07 ha; Planting as needed
	Final cut (if shelterwood system)	Remove remaining future trees once they have reached age of ca. 100 years (deciduous species) or ca. 80 years (coniferous species)
	Clear cut..	None
Short description: introduction of new drought-tolerant Fagus provenances; wood production oriented management including ecological aspects and recreation function,		

Stand x site type 1: Even-aged Fagus sylvatica stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-aged Fagus sylvatica - Soil type: sandy; Nutrients (poor, average, high): poor ; Water(low, average, high): low	
Management alternative	**No.: 8 (increased wood production)** **BAUM/AM: AM** **System**: Future tree selection **Regeneration:**Natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:**variable **Addressed climate change effect**: Drought **Adaptation strategy (B, RI, AC)**: B **Expected level for addressed objectives (low, average, high)**:):timber production (high); carbon sequestration (high), biodiversity (average), increasing drought resistance (average), reducing fire risk (average), reducing storm risk (average), increasing recreational value (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- Regeneration of productive deciduous species, part. Quercus spp. - Due to the high browsing pressure, Q. robur saplings > 1.5m need to be planted
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	Future tree selection, first entry after ca. 25 years, select 60-80 individuals/ha
	Thinning 2	- every 5 years thinning of 100% of annual increment - Ca. 15-20 years after first entry; remove ca. 50% of future trees selected in Thinning 1
Adult	Regeneration cut (if shelterwood system)	None
	Final cut (if shelterwood system)	Remove remaining future trees once they have reached age of ca. 100 years (deciduous species) or ca. 80 years (coniferous species)
	Clear cut.	None
Short description: utilize potential benefits of climate change by harvesting at increased intensity; no efforts to convert to more productive species		

Stand x site type 2: Even-aged Quercus robur and Q. petraea stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-aged Quercus robur and Q. petraea - Soil type: sandy; Nutrients (poor, average, high): poor ; Water(low, average, high): low	
Management alternative	**No.: 1 (integrated Management – low intensity)** **BAUM/AM: BAUM** **System**: Regeneration cut **Regeneration:**Natural **Thinning type (below, above):** NA **Thinning intensity (weak, average, heavy):** None **Entry interval:**unspecified **Addressed climate change effect**: NA **Adaptation strategy (B, RI, AC)**: NA **Expected level for addressed objectives (low, average, high)**:timber production (low); carbon sequestration (low), biodiversity (average), increasing drought resistance (low), reducing fire risk (average), reducing storm risk (average), increasing recreational value (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- Promote regeneration of endemic deciduous species, part. F. sylvatica, Quercus petraea and Q. robur and also Betula pendula - Encourage development of uneven-aged forest structure and tree species diversity - Due to the high browsing pressure, Q. robur saplings > 1.5m need to be planted
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	None
	Thinning 2	None
Adult	Regeneration cut (if shelterwood system)	Only in mast years; remove weak individuals; gap size variable, max. 0.4 ha; depends on focus species (for F. sylvatica regeneration: max. 0.07 ha; for Quercus regeneration 0.15 – 0.4 ha)
	Final cut (if shelterwood system)	None
	Clear cut.	None
Short description: low-intensity, integrated management to improve ecological and recreation function; no commercial use considered.		

Stand x site type 2: Even-aged Quercus robur and Q. petraea stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-aged Quercus robur and Q. petraea - Soil type: sandy; Nutrients (poor, average, high): poor ; Water(low, average, high): low	
Management alternative	**No.: 2 (integrated Management – Wood production)** **BAUM/AM: BAUM** **System**: Future tree selection **Regeneration:** Natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:** variable **Addressed climate change effect**: NA **Adaptation strategy (B, RI, AC)**: NA **Expected level for addressed objectives (low, average, high)**: timber production (average); carbon sequestration (average), biodiversity (average), increasing drought resistance (average), reducing fire risk (average), reducing storm risk (average), increasing recreational value (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- Promote regeneration of endemic deciduous species, part. F. sylvatica, Quercus petraea and Q. robur and also Betula pendula - Encourage development of uneven-aged forest structure and tree species diversity - Due to the high browsing pressure, Q. robur saplings > 1.5m need to be planted
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	Future tree selection, first entry after ca. 25 years, select 60-80 individuals/ha, preferably native deciduous species, and remove competitors
	Thinning 2	- every 5 years thinning of max. 25% of stand to maintain environment for selected future trees - Ca. 15-20 years after first entry; remove ca. 50% of future trees selected in Thinning 1
Adult	Regeneration cut (if shelterwood system)	None
	Final cut (if shelterwood system)	Remove remaining future trees once they have reached age of ca. 100 years (deciduous species) or ca. 80 years (coniferous species)
	Clear cut..	None
Short description: Quercus spp. are the main deciduous species used for wood production for production-oriented land owners. Thinning occurs mainly by future tree selection and removal of competitors.		

Stand x site type 2: Even-aged Quercus robur and Q. petraea stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-aged Quercus robur and Q. petraea - Soil type: sandy; Nutrients (poor, average, high): poor ; Water(low, average, high): low	
Management alternative	**No.: 3 (multifunctional, limited conversion)** **BAUM/AM: AM** **System**: Regeneration cut **Regeneration:**Natural **Thinning type (below, above):** NA **Thinning intensity (weak, average, heavy):** None **Entry interval:**unspecified **Addressed climate change effect**: Drought **Adaptation strategy (B, RI, AC)**: RI **Expected level for addressed objectives (low, average, high)**:):timber production (low); carbon sequestration (average), biodiversity (high), increasing drought resistance (average), reducing fire risk (average), reducing storm risk (average), increasing recreational value (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- Promote regeneration of endemic deciduous species of high tolerance to drought, part. Quercus petraea and Q. robur and also Betula pendula - Encourage development of uneven-aged forest structure - Due to the high browsing pressure, Q. robur saplings > 1.5m need to be planted
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	None
	Thinning 2	None
Adult	Regeneration cut (if shelterwood system)	Natural regeneration: only in mast years; Remove weak individuals; Gap size for Quercus regeneration 0.15 – 0.4 ha; Planting as needed
	Final cut (if shelterwood system)	None
	Clear cut..	None
Short description: low-intensity management aiming at reducing risks from droughts		

Stand x site type 2: Even-aged Quercus robur and Q. petraea stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-aged Quercus robur and Q. petraea - Soil type: sandy; Nutrients (poor, average, high): poor ; Water(low, average, high): low	
Management alternative	**No.: 4 (multifunctional, full conversion)** **BAUM/AM: AM** **System**: Regeneration cut **Regeneration:**Natural **Thinning type (below, above):** NA **Thinning intensity (weak, average, heavy):** None **Entry interval:**unspecified **Addressed climate change effect**: Drought **Adaptation strategy (B, RI, AC)**: AC **Expected level for addressed objectives (low, average, high):)**:timber production (low); carbon sequestration (average), biodiversity (high), increasing drought resistance (high), reducing fire risk (average), reducing storm risk (average), increasing recreational value (high)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- Promote regeneration of drought-tolerant endemic deciduous species (Due to the high browsing pressure, Q. robur saplings > 1.5m need to be planted) - Introduce more drought resistant F. sylvatica provenances by underplanting - Encourage development of uneven-aged forest structure and tree species diversity
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	None
	Thinning 2	None
Adult	Regeneration cut (if shelterwood system)	Natural regeneration: only in mast years; Remove weak individuals; Gap size for F. sylvatica regeneration: max. 0.07 ha; Planting as needed
	Final cut (if shelterwood system)	None
	Clear cut..	None
Short description: in addition to promoting endemic Quercus, introduce new drought-tolerant Fagus provenances; low-intensity management to improve ecological and recreation function, no commercial use;		

Stand x site type 2: Even-aged Quercus robur and Q. petraea stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-aged Quercus robur and Q. petraea - Soil type: sandy; Nutrients (poor, average, high): poor ; Water(low, average, high): low	
Management alternative	**No.: 5 (multifunctional with wood production)** **BAUM/AM: AM** **System**: Future tree selection **Regeneration:**Natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:**variable **Addressed climate change effect**: Drought **Adaptation strategy (B, RI, AC)**: B **Expected level for addressed objectives (low, average, high)**:**)**:timber production (average); carbon sequestration (average), biodiversity (average), increasing drought resistance (average), reducing fire risk (average), reducing storm risk (average), increasing recreational value (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- Regeneration of endemic deciduous species, part. F. sylvatica, Quercus petraea and Q. robur and also Betula pendula - Encourage development of uneven-aged forest structure and tree species diversity - Due to the high browsing pressure, Q. robur saplings > 1.5m need to be planted
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	Future tree selection, first entry after ca. 25 years, select 60-80 individuals/ha, preferably native deciduous species, and remove competitors
	Thinning 2	- every 5 years thinning of max. 25% of stand to maintain environment for selected future trees - Ca. 15-20 years after first entry; remove ca. 50% of future trees selected in Thinning 1
Adult	Regeneration cut (if shelterwood system)	None
	Final cut (if shelterwood system)	Remove remaining future trees once they have reached age of ca. 100 years (deciduous species) or ca. 80 years (coniferous species)
	Clear cut..	None
Short description: utilize potential benefits of climate change by harvesting at moderate intensity; no efforts to convert to more productive species		

Stand x site type 2: Even-aged Quercus robur and Q. petraea stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-aged Quercus robur and Q. petraea - Soil type: sandy; Nutrients (poor, average, high): poor ; Water(low, average, high): low	
Management alternative	**No.: 6 (low wood production, limited conversion)** **BAUM/AM: AM** **System**: Future tree selection **Regeneration:**Natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** low **Entry interval:**variable **Addressed climate change effect**: Drought **Adaptation strategy (B, RI, AC)**: RI **Expected level for addressed objectives (low, average, high):)**:timber production (low); carbon sequestration (average), biodiversity (average), increasing drought resistance (average), reducing fire risk (average), reducing storm risk (average), increasing recreational value (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- Promote regeneration of endemic deciduous species of high tolerance to drought, part. Quercus petraea and Q. robur and also Betula pendula - Encourage development of uneven-aged forest structure - Due to the high browsing pressure, Q. robur saplings > 1.5m need to be planted
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	Future tree selection, first entry after ca. 25 years, select 40-60 individuals/ha
	Thinning 2	- every 5 years thinning of ca. 25% of stand to maintain environment for selected future trees - Ca. 15-20 years after first entry; remove ca. 50% of future trees selected in Thinning 1
Adult	Regeneration cut (if shelterwood system)	Gap size for Quercus regeneration 0.15 – 0.4 ha; Planting as needed
	Final cut (if shelterwood system)	Remove remaining future trees once they have reached age of ca. 100 years (deciduous species) or ca. 80 years (coniferous species)
	Clear cut..	None
Short description: production oriented alternative to low intensity management with focus on reducing risks from climate change		

Stand x site type 2: Even-aged Quercus robur and Q. petraea stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-aged Quercus robur and Q. petraea - Soil type: sandy; Nutrients (poor, average, high): poor ; Water(low, average, high):low	
Management alternative	**No.: 7 (wood production and conversion)** **BAUM/AM: AM** **System**: Future tree selection **Regeneration:**Natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:**variable **Addressed climate change effect**: Drought **Adaptation strategy (B, RI, AC)**: AC **Expected level for addressed objectives (low, average, high)**:):timber production (average); carbon sequestration (average), biodiversity (average), increasing drought resistance (high), reducing fire risk (average), reducing storm risk (average), increasing recreational value (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- Introduce more drought resistant F. sylvatica provenances by underplanting - Promote regeneration of drought-tolerant endemic deciduous species (Due to the high browsing pressure, Q. robur saplings > 1.5m need to be planted) - Encourage development of uneven-aged forest structure and tree species diversity
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	Future tree selection, first entry after ca. 30 years, select 60-80 individuals/ha, preferably native deciduous species, and remove competitors
	Thinning 2	- every 5 years thinning of ca. 25% of stand to maintain environment for selected future trees - Ca. 15-20 years after first entry; remove ca. 50% of future trees selected in Thinning 1
Adult	Regeneration cut (if shelterwood system)	Gap size for F. sylvatica regeneration: max. 0.07 ha; Planting as needed
	Final cut (if shelterwood system)	Remove remaining future trees once they have reached age of ca. 100 years (deciduous species) or ca. 80 years (coniferous species)
	Clear cut..	None
Short description: introduction of new drought-tolerant Fagus provenances in addition to Quercus regeneration; wood production oriented management including ecological aspects and recreation function,		

Stand x site type 2: Even-aged Quercus robur and Q. petraea stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-aged Quercus robur and Q. petraea - Soil type: sandy; Nutrients (poor, average, high): poor ; Water(low, average, high): low	
Management alternative	**No.: 8 (increased wood production)** **BAUM/AM: AM** **System**: Future tree selection **Regeneration:**Natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:**variable **Addressed climate change effect**: Drought **Adaptation strategy (B, RI, AC)**: B **Expected level for addressed objectives (low, average, high):)**:timber production (high); carbon sequestration (high), biodiversity (average), increasing drought resistance (low), reducing fire risk (average), reducing storm risk (average), increasing recreational value (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- Regeneration of productive deciduous species, part. Quercus spp. - Due to the high browsing pressure, Q. robur saplings > 1.5m need to be planted
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	Future tree selection, first entry after ca. 25 years, select 60-80 individuals/ha
	Thinning 2	- every 5 years thinning of 100% of annual increment - Ca. 15-20 years after first entry; remove ca. 50% of future trees selected in Thinning 1
Adult	Regeneration cut (if shelterwood system)	None
	Final cut (if shelterwood system)	Remove remaining future trees once they have reached age of ca. 100 years (deciduous species) or ca. 80 years (coniferous species)
	Clear cut..	None
Short description: utilize potential benefits of climate change by harvesting at increased intensity; no efforts to convert to more productive species		

Stand x site type 3: Uneven-aged Betula pendula - Quercus spp. stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Uneven-aged Betula pendula - Qercus spp. - Soil type: sandy; Nutrients (poor, average, high): poor ; Water(low, average, high): low	
Management alternative	**No.: 1 (integrated Management – low intensity)** **BAUM/AM: BAUM** **System**: Regeneration cut **Regeneration:**Natural **Thinning type (below, above):** NA **Thinning intensity (weak, average, heavy):** None **Entry interval:**unspecified **Addressed climate change effect**: NA **Adaptation strategy (B, RI, AC)**: NA **Expected level for addressed objectives (low, average, high)**:timber production (low); carbon sequestration (low), biodiversity (average), increasing drought resistance (average), reducing fire risk (average), reducing storm risk (average), increasing recreational value (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- Promote regeneration of endemic deciduous species, part. F. sylvatica, Quercus petraea and Q. robur and also Betula pendula - Encourage development of uneven-aged forest structure and tree species diversity - Due to the high browsing pressure, Q. robur saplings > 1.5m need to be planted
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	None
	Thinning 2	None
	……	
Adult	Regeneration cut (if shelterwood system)	Only in mast years; remove weak individuals; gap size variable, max. 0.4 ha; depends on focus species (for F. sylvatica regeneration: max. 0.07 ha; for Quercus regeneration 0.15 – 0.4 ha)
	Final cut (if shelterwood system)	None
	Clear cut..	None
Short description: low-intensity, integrated management to improve ecological and recreation function; no commercial use considered.		

Stand x site type 3: Uneven-aged Betula pendula - Qercus spp. stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Uneven-aged Betula pendula - Qercus spp. - Soil type: sandy; Nutrients (poor, average, high): poor ; Water(low, average, high): low	
Management alternative	**No.: 2 (integrated Management – Wood production)** **BAUM/AM: BAUM** **System**: Future tree selection **Regeneration:**Natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:**variable **Addressed climate change effect**: NA **Adaptation strategy (B, RI, AC)**: NA **Expected level for addressed objectives (low, average, high)**:timber production (average); carbon sequestration (average), biodiversity (average), increasing drought resistance (average), reducing fire risk (average), reducing storm risk (average), increasing recreational value (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- Promote regeneration of endemic deciduous species, part. F. sylvatica, Quercus petraea and Q. robur and also Betula pendula - Encourage development of uneven-aged forest structure and tree species diversity - Due to the high browsing pressure, Q. robur saplings > 1.5m need to be planted
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	Future tree selection, first entry after ca. 25 years, select 60-80 individuals/ha, preferably native deciduous species, and remove competitors
	Thinning 2	- every 5 years thinning of max. 25% of stand to maintain environment for selected future trees - Ca. 15-20 years after first entry; remove ca. 50% of future trees selected in Thinning 1
Adult	Regeneration cut (if shelterwood system)	None
	Final cut (if shelterwood system)	Remove remaining future trees once they have reached age of ca. 100 years (deciduous species) or ca. 80 years (coniferous species)
	Clear cut..	None
Short description: Quercus spp. are the main deciduous species used for wood production for production-oriented land owners. Thinning occurs mainly by future tree selection and removal of competitors.		

Stand x site type 3: Uneven-aged Betula pendula - Qercus spp. stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Uneven-aged Betula pendula - Qercus spp. - Soil type: sandy; Nutrients (poor, average, high): poor ; Water(low, average, high): low	
Management alternative	**No.: 3 (multifunctional, limited conversion)** **BAUM/AM: AM** **System**: Regeneration cut **Regeneration:**Natural **Thinning type (below, above):** NA **Thinning intensity (weak, average, heavy):** None **Entry interval:**unspecified **Addressed climate change effect**: Drought **Adaptation strategy (B, RI, AC)**: RI **Expected level for addressed objectives (low, average, high):)**:timber production (low); carbon sequestration (average), biodiversity (high), increasing drought resistance (high), reducing fire risk (average), reducing storm risk (average), increasing recreational value (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- Due to the high browsing pressure, Q. robur saplings > 1.5m need to be planted
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	None
	Thinning 2	None
Adult	Regeneration cut (if shelterwood system)	Natural regeneration: only in mast years; Remove weak individuals; Gap size for Quercus regeneration 0.15 – 0.4 ha; Planting as needed
	Final cut (if shelterwood system)	None
	Clear cut..	None
Short description: low-intensity management aiming at reducing risks from droughts		

Stand x site type 3: Uneven-aged Betula pendula - Qercus spp. stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Uneven-aged Betula pendula - Qercus spp. - Soil type: sandy; Nutrients (poor, average, high): poor ; Water(low, average, high): low	
Management alternative	**No.: 4 (multifunctional, full conversion)** **BAUM/AM: AM** **System**: Regeneration cut **Regeneration:**Natural **Thinning type (below, above):** NA **Thinning intensity (weak, average, heavy):** None **Entry interval:**unspecified **Addressed climate change effect**: Drought **Adaptation strategy (B, RI, AC)**: AC **Expected level for addressed objectives (low, average, high):)**:timber production (low); carbon sequestration (average), biodiversity (high), increasing drought resistance (high), reducing fire risk (average), reducing storm risk (average), increasing recreational value (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- Promote regeneration of drought-tolerant endemic deciduous species (Due to the high browsing pressure, Q. robur saplings > 1.5m need to be planted) - Introduce more drought resistant F. sylvatica provenances by underplanting
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	None
	Thinning 2	None
Adult	Regeneration cut (if shelterwood system)	Natural regeneration: only in mast years; Remove weak individuals; Gap size for F. sylvatica regeneration: max. 0.07 ha; Planting as needed
	Final cut (if shelterwood system)	None
	Clear cut..	None
Short description: Introduce new drought-tolerant Fagus provenances; low-intensity management to improve ecological and recreation function, no commercial use;		

Stand x site type 3: Uneven-aged Betula pendula - Qercus spp. stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Uneven-aged Betula pendula - Qercus spp. - Soil type: sandy; Nutrients (poor, average, high): poor ; Water(low, average, high): low	
Management alternative	**No.: 5 (multifunctional with wood production)** **BAUM/AM: AM** **System**: Future tree selection **Regeneration:**Natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:**variable **Addressed climate change effect**: Drought **Adaptation strategy (B, RI, AC)**: B **Expected level for addressed objectives (low, average, high)**:**)**:timber production (average); carbon sequestration (average), biodiversity (average), increasing drought resistance (average), reducing fire risk (average), reducing storm risk (average), increasing recreational value (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- Regeneration of endemic deciduous species, part. F. sylvatica, Quercus petraea and Q. robur and also Betula pendula - Due to the high browsing pressure, Q. robur saplings > 1.5m need to be planted
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	Future tree selection, first entry after ca. 25 years, select 60-80 individuals/ha, preferably native deciduous species, and remove competitors
	Thinning 2	- every 5 years thinning of max. 25% of stand to maintain environment for selected future trees - Ca. 15-20 years after first entry; remove ca. 50% of future trees selected in Thinning 1
Adult	Regeneration cut (if shelterwood system)	None
	Final cut (if shelterwood system)	Remove remaining future trees once they have reached age of ca. 100 years (deciduous species) or ca. 80 years (coniferous species)
	Clear cut..	None
Short description: utilize potential benefits of climate change by harvesting at moderate intensity; no efforts to convert to more productive species		

Stand x site type 3: Uneven-aged Betula pendula - Qercus spp. stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Uneven-aged Betula pendula - Qercus spp. - Soil type: sandy; Nutrients (poor, average, high): poor ; Water(low, average, high): low	
Management alternative	**No.: 6 (low wood production, limited conversion)** **BAUM/AM: AM** **System**: Future tree selection **Regeneration:**Natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** low **Entry interval:**variable **Addressed climate change effect**: Drought **Adaptation strategy (B, RI, AC)**: RI **Expected level for addressed objectives (low, average, high):)**:timber production (low); carbon sequestration (average), biodiversity (average), increasing drought resistance (average), reducing fire risk (average), reducing storm risk (average), increasing recreational value (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- Due to the high browsing pressure, Q. robur saplings > 1.5m need to be planted
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	Future tree selection, first entry after ca. 25 years, select 40-60 individuals/ha
	Thinning 2	- every 5 years thinning of ca. 25% of stand to maintain environment for selected future trees - Ca. 15-20 years after first entry; remove ca. 50% of future trees selected in Thinning 1
Adult	Regeneration cut (if shelterwood system)	Gap size for Quercus regeneration 0.15 – 0.4 ha; Planting as needed
	Final cut (if shelterwood system)	Remove remaining future trees once they have reached age of ca. 100 years (deciduous species) or ca. 80 years (coniferous species)
	Clear cut..	None
Short description: production oriented alternative to low intensity management with focus on reducing risks from climate change		

Stand x site type 3: Uneven-aged Betula pendula - Qercus spp. stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Uneven-aged Betula pendula - Qercus spp. - Soil type: sandy; Nutrients (poor, average, high): poor ; Water(low, average, high):low	
Management alternative	**No.: 7 (wood production and conversion)** **BAUM/AM: AM** **System**: Future tree selection **Regeneration:**Natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:**variable **Addressed climate change effect**: Drought **Adaptation strategy (B, RI, AC)**: AC **Expected level for addressed objectives (low, average, high)**:):timber production (average); carbon sequestration (average), biodiversity (average), increasing drought resistance (high), reducing fire risk (average), reducing storm risk (average), increasing recreational value (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- Introduce more drought resistant F. sylvatica provenances by underplanting - Promote regeneration of drought-tolerant endemic deciduous species (Due to the high browsing pressure, Q. robur saplings > 1.5m need to be planted)
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	Future tree selection, first entry after ca. 30 years, select 60-80 individuals/ha, preferably native deciduous species, and remove competitors
	Thinning 2	- every 5 years thinning of ca. 25% of stand to maintain environment for selected future trees - Ca. 15-20 years after first entry; remove ca. 50% of future trees selected in Thinning 1
Adult	Regeneration cut (if shelterwood system)	Gap size for F. sylvatica regeneration: max. 0.07 ha; Planting as needed
	Final cut (if shelterwood system)	Remove remaining future trees once they have reached age of ca. 100 years (deciduous species) or ca. 80 years (coniferous species)
	Clear cut.	None
Short description: introduction of new drought-tolerant Fagus provenances in addition to Quercus regeneration; wood production oriented management including ecological aspects and recreation function,		

Stand x site type 3: Uneven-aged Betula pendula - Qercus spp. stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Uneven-aged Betula pendula - Qercus spp. - Soil type: sandy; Nutrients (poor, average, high): poor ; Water(low, average, high): low	
Management alternative	**No.: 8 (increased wood production)** **BAUM/AM: AM** **System**: Future tree selection **Regeneration:**Natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:**variable **Addressed climate change effect**: Drought **Adaptation strategy (B, RI, AC)**: B **Expected level for addressed objectives (low, average, high):)**:timber production (high); carbon sequestration (high), biodiversity (average), increasing drought resistance (low), reducing fire risk (average), reducing storm risk (average), increasing recreational value (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- Regeneration of productive deciduous species, part. Quercus spp. - Due to the high browsing pressure, Q. robur saplings > 1.5m need to be planted
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	Future tree selection, first entry after ca. 25 years, select 60-80 individuals/ha
	Thinning 2	- every 5 years thinning of 100% of annual increment - Ca. 15-20 years after first entry; remove ca. 50% of future trees selected in Thinning 1
Adult	Regeneration cut (if shelterwood system)	None
	Final cut (if shelterwood system)	Remove remaining future trees once they have reached age of ca. 100 years (deciduous species) or ca. 80 years (coniferous species)
	Clear cut..	None
Short description: utilize potential benefits of climate change by harvesting at increased intensity; no efforts to convert to more productive species		

Stand x site type 4: Even-aged Qercus rubra stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-aged Qercus rubra - Soil type: sandy; Nutrients (poor, average, high): poor ; Water(low, average, high): low	
Management alternative	**No.: 1 (integrated Management – low intensity)** **BAUM/AM: BAUM** **System**: Regeneration cut **Regeneration:**Natural **Thinning type (below, above):** NA **Thinning intensity (weak, average, heavy):** None **Entry interval:**unspecified **Addressed climate change effect**: NA **Adaptation strategy (B, RI, AC)**: NA **Expected level for addressed objectives (low, average, high)**:timber production (low); carbon sequestration (low), biodiversity (average), increasing drought resistance (average), reducing fire risk (average), reducing storm risk (average), increasing recreational value (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- Promote regeneration of endemic deciduous species, part. F. sylvatica, Quercus petraea and Q. robur and also Betula pendula - Encourage development of uneven-aged forest structure and tree species diversity - Due to the high browsing pressure, Q. robur saplings > 1.5m need to be planted
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	None
	Thinning 2	None
	……	
Adult	Regeneration cut (if shelterwood system)	Only in mast years; remove weak individuals; gap size variable, max. 0.4 ha; depends on focus species (for F. sylvatica regeneration: max. 0.07 ha; for Quercus regeneration 0.15 – 0.4 ha)
	Final cut (if shelterwood system)	None
	Clear cut..	None
Short description: low-intensity management to improve ecological and recreation function, no commercial use; Note: no AM alternative as the proportion of the Q. rubra as an introduced species is to be reduced; BAUM will be applied		

Stand x site type 4: Even-aged Qercus rubra stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-aged Qercus rubra - Soil type: sandy; Nutrients (poor, average, high): poor ; Water(low, average, high): low	
Management alternative	**No.: 2 (integrated Management – Wood production)** **BAUM/AM: BAUM** **System**: Future tree selection **Regeneration:**Natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:**variable **Addressed climate change effect**: NA **Adaptation strategy (B, RI, AC)**: NA **Expected level for addressed objectives (low, average, high)**:timber production (average); carbon sequestration (average), biodiversity (average), increasing drought resistance (average), reducing fire risk (average), reducing storm risk (average), increasing recreational value (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- Promote regeneration of endemic deciduous species, part. F. sylvatica, Quercus petraea and Q. robur and also Betula pendula - Encourage development of uneven-aged forest structure and tree species diversity - Due to the high browsing pressure, Q. robur saplings > 1.5m need to be planted
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	Future tree selection, first entry after ca. 25 years, select 60-80 individuals/ha, preferably native deciduous species, and remove competitors
	Thinning 2	- every 5 years thinning of max. 25% of stand to maintain environment for selected future trees - Ca. 15-20 years after first entry; remove ca. 50% of future trees selected in Thinning 1
Adult	Regeneration cut (if shelterwood system)	None
	Final cut (if shelterwood system)	Remove remaining future trees once they have reached age of ca. 100 years (deciduous species) or ca. 80 years (coniferous species)
	Clear cut..	None
Short description: Utilize existing stands of introduced Q. rubra but reduce proportion of this species and promote regeneration of native species; Note: no AM alternative as the proportion of the Q. rubra as an introduced species is to be reduced and native Quercus spp. are to be used instead; BAUM will be applied		

Stand x site type 5: Even-aged Pseudotsuga menziesii stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-aged Pseudotsuga menziesii - Soil type: sandy; Nutrients (poor, average, high): poor ; Water(low, average, high): low	
Management alternative	**No.: 1 (integrated Management – low intensity)** **BAUM/AM:** BAUM **System**: Conversion **Regeneration:** natural **Thinning type (below, above):** below **Thinning intensity (weak, average, heavy):** average **Entry interval:**ca. 10 years **Addressed climate change effect**: NA **Adaptation strategy (B, RI, AC)**: NA **Expected level for addressed objectives (low, average, high)**:timber production (average); carbon sequestration (average), biodiversity (average), increasing drought resistance (average), reducing fire risk (high), reducing storm risk (average), increasing recreational value (high)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	- Promote regeneration of endemic deciduous species, part. F. sylvatica, Quercus petraea and Q. robur and also Betula pendula - Encourage development of uneven-aged forest structure and tree species diversity - Due to the high browsing pressure, Q. robur saplings > 1.5m need to be planted
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	Remove ca. 15% of the old stand, i.e make room for regeneration of Quercus and Fagus and leave ca. 40-60 bestP. menziesii individuals for later harvest and as source of dead wood
	Thinning 2	Every 10 years remove ca. 80% of annual increment
Adult	Regeneration cut (if shelterwood system)	
	Final cut (if shelterwood system)	Remove once remaining P. menziesii individuals at age ca. 80 years
	Clear cut..	
Short description: P. menziesii is an introduced species and its proportion is to be reduced; Note: no AM alternative as the proportion of the P. menziesii as an introduced species is to be reduced; BAUM will be applied		

Stand x site type 5: Even-aged Pseudotsuga menziesii stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-aged Pseudotsuga menziesii - Soil type: sandy; Nutrients (poor, average, high): poor; Water(low, average, high): low	
Management alternative	**No.: 2 (integrated Management – Wood production)** **BAUM/AM:** BAUM **System**: Yield table **Regeneration:** natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:**ca. 5 years **Addressed climate change effect**: NA **Adaptation strategy (B, RI, AC)**: NA **Expected level for addressed objectives (low, average, high)**:timber production (average); carbon sequestration (average), biodiversity (low), increasing drought resistance (average), reducing fire risk (average), reducing storm risk (average), increasing recreational value (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	- Encourage development of uneven-aged forest structure and tree species diversity
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	Thinning to densities specified in yield tables (Jansen et al. 1996. Opbrengsttabellen voor belangrijke boomsoorten in Nederland.)
Adult	Regeneration cut (if shelterwood system)	
	Final cut (if shelterwood system)	
	Clear cut..	
Short description: P. menziesii performs well and is used for wood production.		

Stand x site type 5: Even-aged Pseudotsuga menziesii stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-aged Pseudotsuga menziesii - Soil type: sandy; Nutrients (poor, average, high): poor; Water(low, average, high): low	
Management alternative	**No.:** 3 (low wood production, limited conversion) **BAUM/AM:** AM **System**: Uneven-aged **Regeneration:** natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:**ca. 5 years **Addressed climate change effect**: drought **Adaptation strategy (B, RI, AC)**: RI **Expected level for addressed objectives (low, average, high)**:timber production (low); carbon sequestration (average), biodiversity (average), increasing drought resistance (average), reducing fire risk (high), reducing storm risk (high), increasing recreational value (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- P. menziesii may be planted on richer sites to increase yield - Encourage development of uneven-aged forest structure and tree species diversity
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	maintain an exponentially decreasingdiameter distribution: ca. $N_j = N^{1.3}_{j+1}$ where N_j is stems in diameter class j; max. dbh 100cm
Adult	Regeneration cut (if shelterwood system)	
	Final cut (if shelterwood system)	
	Clear cut..	
Short description: P. menziesii is expected to perform well even under moderately increased drought conditions and is thus a good commercial species. An uneven-aged harvesting system is applied that contributes a) to reduce the risk of storm damage and b) maximizing annual increment (cf. Schelhaas 2008. Forestry 81 (3):399-414); regeneration of endemic deciduous species is encouraged		

Stand x site type 5: Even-aged Pseudotsuga menziesii stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-aged Pseudotsuga menziesii - Soil type: sandy; Nutrients (poor, average, high): poor; Water(low, average, high): low	
Management alternative	**No.: 4 (wood production and conversion)** **BAUM/AM: AM** **System**: Uneven-aged **Regeneration:** natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:**ca. 5 years **Addressed climate change effect**: drought **Adaptation strategy (B, RI, AC)**: AC **Expected level for addressed objectives (low, average, high)**:timber production (average); carbon sequestration (average), biodiversity (high), increasing drought resistance (high), reducing fire risk (high), reducing storm risk (high), increasing recreational value (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- P. menziesii may be planted on richer sites to increase yield - Encourage development of uneven-aged forest structure and tree species diversity - Introduce more drought-tolerant F. sylvatica provenances - Q. robur saplings may need planting to due to high browsing pressure
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	maintain an exponentially decreasingdiameter distribution: ca. $N_j = N^{1.3}_{j+1}$ where N_j is stems in diameter class j; max. dbh 80cm
Adult	Regeneration cut (if shelterwood system)	Only in mast years; remove weak individuals; gap size variable, max. 0.4 ha; depends on focus species (for F. sylvatica regeneration: max. 0.07 ha; for Quercus regeneration 0.15 – 0.4 ha)
	Final cut (if shelterwood system)	
	Clear cut..	
Short description: P. menziesii is expected to perform well even under moderately increased drought conditions and is thus a good commercial species. An uneven-aged harvesting system is applied that contributes a) to reduce the risk of storm damage and b) maximizing annual increment (cf. Schelhaas 2008. Forestry 81 (3):399-414); regeneration of drought-tolerant deciduous species is actively promoted		

Stand x site type 5: Even-aged Pseudotsuga menziesii stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-aged Pseudotsuga menziesii - Soil type: sandy; Nutrients (poor, average, high): poor; Water(low, average, high): low	
Management alternative	**No.: 5 (increased wood production)** **BAUM/AM: AM** **System**: Uneven-aged **Regeneration:** natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:**ca. 5 years **Addressed climate change effect**: drought **Adaptation strategy (B, RI, AC)**: B **Expected level for addressed objectives (low, average, high)**:timber production (high); carbon sequestration (average), biodiversity (low), increasing drought resistance (average), reducing fire risk (average), reducing storm risk (high), increasing recreational value (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- P. menziesii may be planted on richer sites to increase yield
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	maintain an exponentially decreasingdiameter distribution: ca. $N_j = N^{1.3}_{j+1}$ where N_j is stems in diameter class j; max. dbh 60cm
Adult	Regeneration cut (if shelterwood system)	
	Final cut (if shelterwood system)	
	Clear cut..	
Short description: P. menziesii is expected to perform well even under moderately increased drought conditions and is thus a good commercial species. An uneven-aged harvesting system is applied that contributes a) to reduce the risk of storm damage and b) maximizing annual increment (cf. Schelhaas 2008. Forestry 81 (3):399-414); increase thinning intensity as increased increment allows		

Stand x site type 6: Even-aged Pinus sylvestris stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-aged Pinus sylvestris - Soil type: sandy; Nutrients (poor, average, high): poor ; Water(low, average, high): low	
Management alternative	**No.: 1 (integrated Management – low intensity)** **BAUM/AM:** BAUM **System**: Conversion **Regeneration:** natural **Thinning type (below, above):** below **Thinning intensity (weak, average, heavy):** average **Entry interval:**ca. 10 years **Addressed climate change effect**: NA **Adaptation strategy (B, RI, AC)**: NA **Expected level for addressed objectives (low, average, high)**: timber production (average); carbon sequestration (average), biodiversity (average), increasing drought resistance (average), reducing fire risk (high), reducing storm risk (average), increasing recreational value (high)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	- Promote regeneration of endemic deciduous species, part. F. sylvatica, Quercus petraea and Q. robur and also Betula pendula - Encourage development of uneven-aged forest structure and tree species diversity - Due to the high browsing pressure, Q. robur saplings > 1.5m need to be planted
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	Remove ca. 15% of the old stand, i.e make room for regeneration of Quercus and Fagus and leave ca. 40-60 bestP. sylvestris individuals for later harvest and as source of dead wood
	Thinning 2	Every 10 years remove ca. 80% of annual increment
Adult	Regeneration cut (if shelterwood system)	
	Final cut (if shelterwood system)	Remove once remaining P. sylvestris individuals at age ca. 80 years
	Clear cut..	
Short description: P. sylvestris is by far the most common species as it was the main species planted since the area was afforested/reforested starting ca. 200 years ago. Its proportion is to be reduced; Note: no AM alternative as the proportion of the P. sylvestris is to be reduced; BAUM will be applied		

Stand x site type 6: Even-aged Pinus sylvestris stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-aged Pinus sylvestris - Soil type: sandy; Nutrients (poor, average, high): poor; Water(low, average, high): low	
Management alternative	**No.: 2 (integrated Management – Wood production)** **BAUM/AM:** BAUM **System**: Yield table **Regeneration:** natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:**ca. 5 years **Addressed climate change effect**: NA **Adaptation strategy (B, RI, AC)**: NA **Expected level for addressed objectives (low, average, high)**:timber production (average); carbon sequestration (average), biodiversity (low), increasing drought resistance (average), reducing fire risk (average), reducing storm risk (average), increasing recreational value (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	- Encourage development of uneven-aged forest structure and tree species diversity - Favor more productive P. menziesii where suitable
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	Thinning to densities specified in yield tables (Jansen et al. 1996. Opbrengsttabellen voor belangrijke boomsoorten in Nederland.)
Adult	Regeneration cut (if shelterwood system)	
	Final cut (if shelterwood system)	
	Clear cut..	
Short description: P. sylvestris is very common and used for wood production; where feasible the more productive P. menziesii can be encouraged over P. sylvestris.		

Stand x site type 6: Even-aged Pinus sylvestris stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-aged Pinus sylvestris - Soil type: sandy; Nutrients (poor, average, high): poor; Water(low, average, high): low	
Management alternative	**No.: 3 (low wood production, limited conversion)** **BAUM/AM: AM** **System**: Uneven-aged **Regeneration:** natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:**ca. 5 years **Addressed climate change effect**: drought **Adaptation strategy (B, RI, AC)**: RI **Expected level for addressed objectives (low, average, high)**:timber production (low); carbon sequestration (average), biodiversity (average), increasing drought resistance (average), reducing fire risk (high), reducing storm risk (high), increasing recreational value (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- P. menziesii may be planted on richer sites to increase yield - Encourage development of uneven-aged forest structure and tree species diversity
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	maintain an exponentially decreasingdiameter distribution: ca. $N_j = N^{1.3}_{j+1}$ where N_j is stems in diameter class j; max. dbh 90cm
Adult	Regeneration cut (if shelterwood system)	
	Final cut (if shelterwood system)	
	Clear cut..	
Short description:		

Stand x site type 6: Even-aged Pinus sylvestris stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-aged Pinus sylvestris - Soil type: sandy; Nutrients (poor, average, high): poor; Water(low, average, high): low	
Management alternative	**No.:** **4 (wood production and conversion)** **BAUM/AM:** **AM** **System**: Uneven-aged **Regeneration:** natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:**ca. 5 years **Addressed climate change effect**: drought **Adaptation strategy (B, RI, AC)**: AC **Expected level for addressed objectives (low, average, high)**:timber production (average); carbon sequestration (average), biodiversity (high), increasing drought resistance (high), reducing fire risk (high), reducing storm risk (high), increasing recreational value (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- P. menziesii may be planted on richer sites to increase yield - Encourage development of uneven-aged forest structure and tree species diversity - Introduce more drought-tolerant F. sylvatica provenances - Q. robur saplings may need planting to due to high browsing pressure
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	maintain an exponentially decreasingdiameter distribution: ca. $N_j = N^{1.3}{}_{j+1}$ where N_j is stems in diameter class j; max. dbh 70cm
Adult	Regeneration cut (if shelterwood system)	Only in mast years; remove weak individuals; gap size variable, max. 0.4 ha; depends on focus species (for F. sylvatica regeneration: max. 0.07 ha; for Quercus regeneration 0.15 – 0.4 ha)
	Final cut (if shelterwood system)	
	Clear cut..	
Short description: diversification of P. sylvestris stands is actively promoted		

Stand x site type 6: Even-aged Pinus sylvestris stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-aged Pinus sylvestris - Soil type: sandy; Nutrients (poor, average, high): poor; Water(low, average, high): low	
Management alternative	**No.: 5 (increased wood production)** **BAUM/AM: AM** **System**: Uneven-aged **Regeneration:** natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:**ca. 5 years **Addressed climate change effect**: drought **Adaptation strategy (B, RI, AC)**: B **Expected level for addressed objectives (low, average, high)**:timber production (high); carbon sequestration (average), biodiversity (low), increasing drought resistance (average), reducing fire risk (average), reducing storm risk (high), increasing recreational value (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- P. menziesii may be planted on richer sites to increase yield
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	maintain an exponentially decreasingdiameter distribution: ca. $N_j = N^{1.3}{}_{j+1}$ where N_j is stems in diameter class j; max. dbh 50cm
Adult	Regeneration cut (if shelterwood system)	
	Final cut (if shelterwood system)	
	Clear cut..	
Short description: increase thinning intensity as increased increment allows; encourage more productive P. menziesii where suitable		

Stand x site type 7: Even-aged Larix kaempferi/decidua stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-agedLarix kaempferi/decidua - Soil type: sandy; Nutrients (poor, average, high): poor ; Water(low, average, high): low	
Management alternative	**No.: 1 (integrated Management – low intensity)** **BAUM/AM:** BAUM **System**: Conversion **Regeneration:** natural **Thinning type (below, above):** below **Thinning intensity (weak, average, heavy):** average **Entry interval:**ca. 10 years **Addressed climate change effect**: NA **Adaptation strategy (B, RI, AC)**: NA **Expected level for addressed objectives (low, average, high)**: timber production (average); carbon sequestration (average), biodiversity (average), increasing drought resistance (average), reducing fire risk (high), reducing storm risk (average), increasing recreational value (high)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	- Promote regeneration of endemic deciduous species, part. F. sylvatica, Quercus petraea and Q. robur and also Betula pendula - Encourage development of uneven-aged forest structure and tree species diversity - Due to the high browsing pressure, Q. robur saplings > 1.5m need to be planted
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	Remove ca. 15% of the old stand, i.e make room for regeneration of Quercus and Fagus and leave ca. 40-60 bestLarix individuals for later harvest and as source of dead wood
	Thinning 2	Every 10 years remove ca. 80% of annual increment
Adult	Regeneration cut (if shelterwood system)	
	Final cut (if shelterwood system)	Remove once remaining Larix individuals at age ca. 80 years
	Clear cut..	
Short description: Larix kaempferi is the more common of the two Larix species. Both are non-native species and their proportion is to be reduced; Note: no AM alternative as the proportion of the Larix is to be reduced; BAUM will be applied		

Stand x site type 7: Even-aged Larix kaempferi/decidua stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-agedLarix kaempferi/decidua - Soil type: sandy; Nutrients (poor, average, high): poor; Water(low, average, high): low	
Management alternative	**No.: 2 (integrated Management – Wood production)** **BAUM/AM:** BAUM **System**: Yield table **Regeneration:** natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:**ca. 5 years **Addressed climate change effect**: NA **Adaptation strategy (B, RI, AC)**: NA **Expected level for addressed objectives (low, average, high)**:timber production (average); carbon sequestration (average), biodiversity (low), increasing drought resistance (average), reducing fire risk (average), reducing storm risk (average), increasing recreational value (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	- Encourage development of uneven-aged forest structure and tree species diversity - Favor more productive P. menziesii where suitable
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	Thinning to densities specified in yield tables (Jansen et al. 1996. Opbrengsttabellen voor belangrijke boomsoorten in Nederland.)
Adult	Regeneration cut (if shelterwood system)	
	Final cut (if shelterwood system)	
	Clear cut..	
Short description: Although the proportion of Larix is to be reduced, the species has good commercial value and is regenerating and growing well despite the high browsing pressure.		

Stand x site type 7: Even-aged Larix kaempferi/decidua stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-agedLarix kaempferi/decidua - Soil type: sandy; Nutrients (poor, average, high): poor; Water(low, average, high): low	
Management alternative	**No.: 3 (low wood production, limited conversion)** **BAUM/AM: AM** **System**: Uneven-aged **Regeneration:** natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:**ca. 5 years **Addressed climate change effect**: drought **Adaptation strategy (B, RI, AC)**: RI **Expected level for addressed objectives (low, average, high)**:timber production (low); carbon sequestration (average), biodiversity (average), increasing drought resistance (average), reducing fire risk (high), reducing storm risk (high), increasing recreational value (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- P. menziesii may be planted on richer sites to increase yield - Encourage development of uneven-aged forest structure and tree species diversity
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	maintain an exponentially decreasingdiameter distribution: ca. $N_j = N^{1.3}{}_{j+1}$ where N_j is stems in diameter class j; max. dbh 90cm
Adult	Regeneration cut (if shelterwood system)	
	Final cut (if shelterwood system)	
	Clear cut..	
Short description:		

Stand x site type 7: Even-aged Larix kaempferi/decidua stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-agedLarix kaempferi/decidua - Soil type: sandy; Nutrients (poor, average, high): poor; Water(low, average, high): low	
Management alternative	**No.: 4 (wood production and conversion)** **BAUM/AM: AM** **System**: Uneven-aged **Regeneration:** natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:**ca. 5 years **Addressed climate change effect**: drought **Adaptation strategy (B, RI, AC)**: AC **Expected level for addressed objectives (low, average, high)**:timber production (average); carbon sequestration (average), biodiversity (high), increasing drought resistance (high), reducing fire risk (high), reducing storm risk (high), increasing recreational value (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- P. menziesii may be planted on richer sites to increase yield - Encourage development of uneven-aged forest structure and tree species diversity - Introduce more drought-tolerant F. sylvatica provenances - Q. robur saplings may need planting to due to high browsing pressure
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	maintain an exponentially decreasingdiameter distribution: ca. $N_j = N^{1.3}_{j+1}$ where N_j is stems in diameter class j; max. dbh 70cm
Adult	Regeneration cut (if shelterwood system)	Only in mast years; remove weak individuals; gap size variable, max. 0.4 ha; depends on focus species (for F. sylvatica regeneration: max. 0.07 ha; for Quercus regeneration 0.15 – 0.4 ha)
	Final cut (if shelterwood system)	
	Clear cut..	
Short description: diversification of Larix stands is actively promoted		

Stand x site type 7: Even-aged Larix kaempferi/decidua stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-agedLarix kaempferi/decidua - Soil type: sandy; Nutrients (poor, average, high): poor; Water(low, average, high): low	
Management alternative	**No.: 5 (increased wood production)** **BAUM/AM: AM** **System**: Uneven-aged **Regeneration:** natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:**ca. 5 years **Addressed climate change effect**: drought **Adaptation strategy (B, RI, AC)**: B **Expected level for addressed objectives (low, average, high)**:timber production (high); carbon sequestration (average), biodiversity (low), increasing drought resistance (average), reducing fire risk (average), reducing storm risk (high), increasing recreational value (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration / planting	- P. menziesii may be planted on richer sites to increase yield
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	maintain an exponentially decreasingdiameter distribution: ca. $N_j = N^{1.3}_{j+1}$ where N_j is stems in diameter class j; max. dbh 50cm
Adult	Regeneration cut (if shelterwood system)	
	Final cut (if shelterwood system)	
	Clear cut..	
Short description: increase thinning intensity as increased increment allows; encourage more productive P. menziesii where suitable		

Stand x site type8: Even-aged Pinus nigra stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-aged Pinus nigra - Soil type: sandy; Nutrients (poor, average, high): poor; Water(low, average, high): low	
Management alternative	**No.: 1 (integrated Management – low intensity)** **BAUM/AM:** BAUM **System**: conversion **Regeneration:** natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:**ca. 10 years **Addressed climate change effect**: NA **Adaptation strategy (B, RI, AC)**: NA **Expected level for addressed objectives (low, average, high)**:timber production (average); carbon sequestration (average), biodiversity (high), increasing drought resistance (average), reducing fire risk (high), reducing storm risk (high), increasing recreational value (high)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	- Promote regeneration of endemic deciduous species, part. F. sylvatica, Quercus petraea and Q. robur and also Betula pendula - Encourage development of uneven-aged forest structure and tree species diversity - Due to the high browsing pressure, Q. robur saplings > 1.5m need to be planted
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	Remove ca. 15% of the old stand, i.e make room for regeneration of Quercus and Fagus and leave ca. 40-60 bestP. nigra individuals for later harvest and as source of dead wood
	Thinning 2	Every 10 years remove ca. 80% of annual increment
Adult	Regeneration cut (if shelterwood system)	
	Final cut (if shelterwood system)	Remove once remaining good P. nigra individuals at age ca. 80 years
	Clear cut..	
Short description: P. nigra is a non-native species that is to be removed. Living individuals of good quality can serve as one-time additional source of income until species is removed; Note: no AM alternative as the species is to be removed; BAUM will be applied		

Stand x site type9: Even-aged Picea abies stands, site 1 (soil type: sandy, nutrients: poor, water: low)

Case study	Atlantic Veluwe	
Stand x site type	- Even-aged Picea abies - Soil type: sandy; Nutrients (poor, average, high): poor; Water(low, average, high): low	
Management alternative	**No.: 1 (integrated Management – low intensity)** **BAUM/AM:** BAUM **System**: Regeneration cut **Regeneration:** natural **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:**ca. 10 years **Addressed climate change effect**: NA **Adaptation strategy (B, RI, AC)**: NA **Expected level for addressed objectives (low, average, high)**:timber production (average); carbon sequestration (average), biodiversity (high), increasing drought resistance (high), reducing fire risk (high), reducing storm risk (high), increasing recreational value (high)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	- Promote regeneration of endemic deciduous species, part. F. sylvatica, Quercus petraea and Q. robur and also Betula pendula - Encourage development of uneven-aged forest structure and tree species diversity - Due to the high browsing pressure, Q. robur saplings > 1.5m need to be planted
Young	Tending	None, as denser growth limits access for deer and associated damage; natural thinning reduces density and promotes good quality
Medium	Thinning 1	Remove ca. 15% of the old stand, i.e make room for regeneration of Quercus and Fagus and leave ca. 40-60 bestP. abies individuals for later harvest and as source of dead wood
	Thinning 2	Every 10 years remove ca. 80% of annual increment
Adult	Regeneration cut (if shelterwood system)	
	Final cut (if shelterwood system)	Remove once remaining good P. abies individuals at age ca. 80 years
	Clear cut..	
Short description: P. abies is a non-native species that is to be removed. Living individuals of good quality can serve as one-time additional source of income until species is removed; Note: no AM alternative as the species is to be removed; BAUM will be applied		

Central Black forest case (3a1, LandClim)

Description: We grouped the management regimes by management system: even-aged and uneven-aged. In our case study (Black forest) the higher elevation sites (stand/site type 1) are currently or have until recently been managed as even-aged Norway spruce plantations. The lower elevation sites (stand/site type 2) are managed as uneven-aged mixed forests. We defined the BAUM for each of those stand/site types as well as 3 AM alternatives each. However, we will apply the uneven-aged management systems also to the currently even-aged managed sites in order simulate different conversion regimes. Vice-versa we will apply the "oak-conversion regime" (which consists of an even-aged conversion part and an uneven-aged target diameter harvest part) also to the currently uneven-aged sites.

Even-aged management systems

Case study	Black forest, LandClim	
Stand 1 site type 1	- Even-aged Norway spruce pure stands - Soil type: xxx ; Nutrients[7]: xxx ; Water[1]: average	
Management alternative	**No.: 1** **BAUM/AM:** BAUM **System**: Intensive even-aged Norway spruce management **Regeneration:** Clear-cut, planting **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** heavy **Entry interval:** 10y **Addressed climate change effect**: N/A **Adaptation strategy (B, RI, AC)**: N/A **Expected level for addressed objectives (low, average, high)**: Timber production: high; biodiversity: low;	
Phase of development	**Process**	**Description**
Regeneration	Planting	4000 Norway spruce trees/ha
Young	Tending	Dbh < 12 cm: Tending to 1750 spruce stems/ha and 88 (5%) other stems/ha
Medium	Thinning 1	$D_{dom} \geq 18$ cm: Thinning to 600 spruce stems/ha and 30 other stems/ha
	Thinning 2	$D_{dom} \geq 27$ cm: Thinning to 300 spruce stems/ha and 15 stems/ha
Adult	Regeneration cut (if shelterwood system)	--
	Final cut (if shelterwood system)	--
	Clear cut	$D_{dom} \geq 45$ cm: Clear cut
Short description: The main objective is the profitable production of timber in even-aged monocultures with less than 20% mixed in other species. The above algorithm and it's quantification is based on the description of intensive even-aged Norway spruce forestry specific to Baden-Württemberg in the EFORWOOD D2.1.3 (Duncker et al. 2007) and was adapted to the LandClim harvesting module.		

[7] "Nutrients" refers to (content x availability); "Water" refers to (holding capacity x availability)

Case study	Black forest, LandClim	
Stand 1 site type 1	- Even-aged Norway spruce pure stands - Soil type: xxx ; Nutrients: xxx ; Water: average	
Management alternative	**No.: 2** **BAUM/AM:** AM **System**: Intensive even-aged Norway spruce management **Regeneration:** Clear-cut, planting **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** heavy **Entry interval:** 10y **Addressed climate change effect**: risk of drought spells, windthrow and insect mortality **Adaptation strategy (B, RI, AC)**: RI **Expected level for addressed objectives (low, average, high)**: Timber production: average; biodiversity: low	
Phase of development	**Process**	**Description**
Regeneration	Planting	4000 Norway spruce trees/ha
Young	Tending	Dbh < 12 cm: tending to 1750 spruce stems/ha and 88 (5%) other stems/ha
Medium	Thinning 1	D_{dom} ≥ 18 cm: Thinning to 600 spruce stems/ha and 30 other stems/ha
	Thinning 2	Not applied
Adult	Regeneration cut (if shelterwood system)	--
	Final cut (if shelterwood system)	--
	Clear cut..	D_{dom} ≥ 28 cm: Clear cut

Short description: By reducing the rotation length, i.e. the clear cut-threshold, the risk of drought and disturbance (RI) mortality is minimized. Due to earlier thinning and harvest and thus lower growing stock timber production is expected to be lower than under BAUM.

Case study	Black forest, LandClim	
Stand 1, site type 1	- Even-aged Norway spruce pure stands - Soil type: xxx ; Nutrients: xxx ; Water: average	
Management alternative	**No.:** 3 **BAUM/AM:** AM **System**: Shelterwood system: Conversion of even-aged spruce Norway spruce forest to uneven-aged mixed oak forest within 40 years **Regeneration:** Shelterwood cut, planting **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** heavy **Entry interval:** 10y **Addressed climate change effect**: increased temperatures, drought, risk of drought spells, windthrow and insect mortality **Adaptation strategy (B, RI, AC)**: B, RI, AC **Expected level for addressed objectives (low, average, high)**: Timber production: low-average; biodiversity: high;	
Phase of development	**Process**	**Description**
Regeneration	Planting	2667 Downy oak trees/ha during conversion. (Applied after 1. and 2. “conversion regeneration cut”)
	Natural regeneration	Allowed for all other species throughout the whole conversion phase
Young	Tending	Tending of 70% of Douglas firs < 12 cm DBH
Medium	Thinning 1	Thinning of 70% of Douglas firs 32 – 48 cm DBH
Adult	1. “Conversion regeneration cut”	Harvest 50% of trees except for drought adapted species (*Larix decidua, Pinus sylvestris, Sorbus aucuparia, Castanea sativa, Quercus pubescens, Sorbus aria, Tilia cordata, …*)
	2. “Conversion regeneration cut”	30 years after 1. “Conversion regeneration cut harvest 50% of trees except for drought adapted species (*Larix decidua, Pinus sylvestris, Sorbus aucuparia, Castanea sativa, Quercus pubescens, Sorbus aria, Tilia cordata, …*)

Short description: This conversion regime aims to adapt (B) the forest to increased temperatures and drought expected with climate change. The strategy is to convert the current drought threatened even-aged or uneven-aged Norway spruce forest to a more drought and disturbance resistant (RI) mixed oak forest. The promotion of a range of drought adapted species and the conversion to an uneven-aged stand structure fosters biodiversity and thus AC. The conversion of the present Norway spruce forest is undertaken by two shelterwood cuts (“Conversion regeneration cuts”). Starting from an adult Norway spruce stand, 50% of all trees except for the drought adapted species are harvested. In the gaps resulting from the 1. “conversion regeneration cut” downy oak (*Quercus pubescens*) is underplanted. After 30 years the old (Norway spruce) stock is further reduced by the 2. “conversion regeneration cut” followed by again an underplanting of oaks in the new gaps. Natural regeneration of other species is allowed throughout the conversion phase. Douglas fir is suppressed by tending and thinning in order to promote the less competitive oaks and other drought adapted species.After that conversion phase a target diameter harvest system is applied to the resulting uneven-aged oak forest (see uneven-aged management system Nr: 5).
1. Note: This management regime aims to convert a Norway spruce forest to a mixed oak forest within 40 years. It is only applied once and should not be viewed as cyclic. It is followed by a target diameter harvest system described under the uneven-aged management system Nr: 5
2. Note: This conversion regime can be applied to both even-aged and uneven-aged Norway spruce

forests (Stand/site type 1 and 2).		
Case study	Black forest, LandClim	
Stand 1 site type 1	- Even-aged Norway spruce pure stands - Soil type: xxx ; Nutrients: xxx ; Water: average	
Management alternative	**No.:** **4** **BAUM/AM:** AM **System**: Intensive even-aged management: Conversion to Douglas fir plantation **Regeneration:** Clear-cut, planting **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** heavy **Entry interval:** 10y **Addressed climate change effect**: increased temperature **Adaptation strategy (B, RI, AC)**: B **Expected level for addressed objectives (low, average, high)**: Timber production: high; biodiversity: low;	
Phase of development	**Process**	**Description**
Regeneration	Planting	4000 Douglas fir trees/ha
Young	Tending	Dbh < 12 cm: Tending to 1750 Douglas fir stems/ha and 88 (5%) other stems/ha
Medium	Thinning 1	D_{dom} ≥ 18 cm: Thinning to 600 Douglas fir stems/ha and 30 other stems/ha
	Thinning 2	D_{dom} ≥ 27 cm: Thinning to 300 Douglas fir stems/ha and 15 stems/ha
Adult	Regeneration cut (if shelterwood system)	--
	Final cut (if shelterwood system)	--
	Clear cut	D_{dom} ≥ 45 cm: Clear cut
Short description: The main objective is the profitable production of timber in even-aged monocultures with less than 20% mixed in other species. The above algorithm is the same as the BAUM with the difference that Norway spruce was replaced by Douglas fir. Utilizing Douglas firs superiority towards other tree species in terms of growth rate and competitiveness under elevated temperatures (B) high timber yield is expected from such plantations. Biodiversity in these even-aged monocultures is expected to be low.		

Uneven-aged management systems

Case study	Black forest, LandClim			
Stand 2 site type 2	- Uneven-aged mixed Norway spruce, silver fir and beech stands - Soil type: xxx ; Nutrients: xxx ; Water: low			
Management alternative	**Nr: 1** **BAUM/ AM:** BAUM **System**: Uneven-aged "Combined-objective forestry" **Selection cuttings intensity (weak, average, heavy):** average **Addressed climate change effect**: N/A **Adaptation strategy (B, RI, AC)**: N/A **Expected level for addressed objectives (low, average, high)**: Timber production: average; biodiversity: average			
Cutting cycle	10 years			
Threshold basal area for management	--			
Diameter class	**0-12 cm**	**32-48 cm**	**>48 cm**	**>100 cm**
Harvest intensity (HI), in trees %	Norway spruce = 0 Silver fir = 0 Others = 30	Norway spruce = 0 Silver fir = 0 Others = 30	All species = 80	--

Short description:
The aim of mixed forest management is the provision of timber, wild-life habitat, biodiversity and recreation opportunities simultaneously ("Combined objective forestry"). For economic reasons high proportions of Norway spruce can be maintained also on sites, where it does not occur. Mixed forest management aims at a structurally rich Norway spruce dominated perpetual forest, whereby naturally regenerating deciduous tree species and silver fir contribute 20 to 40% to the species mixture. The preferred harvesting method is target diameter harvest, whereby target trees are harvested individually or in groups. The species mixture is controlled by tending young development phases and medium development phases are thinned to promote the future crop trees Norway spruce and silver fir.

Note: This BAUM management regime of the the stand/site type 2 is applied to stand/site type 1 as a conversion regime aiming to transfer the even-aged spruce forest a mixed spruce, fir, beech forest.

Case study	Black forest, LandClim			
Stand 2 site type 2	- Uneven-aged mixed Norway spruce, silver fir and beech stands - Soil type: xxx ; Nutrients: xxx ; Water: low			
Management alternative	**Nr:**2 **BAUM/ AM:** AM **System**: Uneven-aged "Combined-objective forestry": **Selection cuttings intensity (weak, average, heavy):** average **Addressed climate change effect**: risk of drought spells, windthrow and insect mortality **Adaptation strategy (B, RI, AC)**: RI **Expected level for addressed objectives (low, average, high)**: Timber production: average; biodiversity: average			
Cutting cycle	10 years			
Threshold basal area for management	--			
Diameter class	**0-12 cm**	**>32 cm**	**>48 cm**	**>100 cm**
Harvest intensity (HI), in trees %	Norway spruce = 0 Silver fir = 0 Others = 30	All species = 80	--	--

Short description:
Compared to BAUM trees are harvested earlier to minimize the risk of disturbance losses (RI). Total timber yield is expected to be similar as under BAUM, whereas the frequency of harvested small diameter trees is increased at the expense of valuable large diameter trees. In terms of biodiversity the loss of large diameter trees is compensated by more light at the forest floor.¨

Note: This conversion regime can be applied to both even-aged and uneven-aged Norway spruce forests (Stand/site type 1 and 2).

<table>
<tr><td>Case study</td><td colspan="4">Black forest, LandClim</td></tr>
<tr><td>Stand x site type</td><td colspan="4">- Uneven-aged mixed Norway spruce, silver fir and beech stands
- Soil type: xxx ; Nutrients: xxx ; Water: low</td></tr>
<tr><td>Management alternative</td><td colspan="4">Nr:3
BAUM/ AM
System: Uneven-aged “Combined-objective forestry”: Promotion of Douglas fir/Silver fir
Selection cuttings intensity (weak, average, heavy): heavy
Addressed climate change effect: increased temperatures, risk of drought spells, windthrow and insect mortality
Adaptation strategy (B, RI, AC): B, RI
Expected level for addressed objectives (low, average, high):
Timber production: high; biodiversity: low</td></tr>
<tr><td>Cutting cycle</td><td colspan="4">10 years</td></tr>
<tr><td>Threshold basal area for management</td><td colspan="4">--</td></tr>
<tr><td>Diameter class</td><td>0-12 cm</td><td>32-48 cm</td><td>>48 cm</td><td>>100 cm</td></tr>
<tr><td>Harvest intensity (HI), in trees %</td><td>Douglas fir= 0
Silver fir = 0
Others = 70</td><td>Douglas fir= 0
Silver fir = 0
Others = 70</td><td>Norway spruce = 100
Others = 80</td><td>--</td></tr>
<tr><td colspan="5">Short description:
In order to adapt (B) the mixed Norway spruce/silver fir/beech forests to expected higher temperatures and moderate changes in precipitation both Douglas and silver fir are promoted, whereas other species including Norway spruce are heavily thinned. Particularly Douglas fir is considered to cope well with the projected temperature rise. Therefore high timber revenues are expected from the promoted Douglas firs. To account for an increased storm risk (RI) the production target is chosen lower (48 cm dbh) than what is common for Douglas fir stands at present (~80 cm). Whereas stand stability is maintained by the uneven-aged management regime, tree-diversity is expected to decrease due to the dominance of Douglas and silver fir.

Note: This conversion regime can be applied to both even-aged and uneven-aged Norway spruce forests (Stand/site type 1 and 2).</td></tr>
</table>

<table>
<tr><td>Case study</td><td colspan="4">Black forest, LandClim</td></tr>
<tr><td>Stand x site type</td><td colspan="4">- Uneven-aged mixed Norway spruce, silver fir and beech stands
- Soil type: xxx ; Nutrients: xxx ; Water: low</td></tr>
<tr><td>Management alternative</td><td colspan="4">Nr:4
BAUM/ AM
System: Uneven-aged “Combined-objective forestry”: Promotion of natural vegetation
Selection cuttings intensity (weak, average, heavy): heavy
Addressed climate change effect: risk of drought spells, windthrow and insect mortality
Adaptation strategy (B, RI, AC): RI, AC
Expected level for addressed objectives (low, average, high):
Timber production: low; biodiversity: high</td></tr>
<tr><td>Cutting cycle</td><td colspan="4">10 years</td></tr>
<tr><td>Threshold basal area for management</td><td colspan="4">--</td></tr>
<tr><td>Diameter class</td><td>0-12 cm</td><td>32-48 cm</td><td>>48 cm</td><td>>100 cm</td></tr>
<tr><td>Harvest intensity (HI), in trees %</td><td>Norway spruce = 70
Others = 0</td><td>Norway spruce = 70
Others = 0</td><td>Norway spruce = 100
Others = 0</td><td>All species = 5</td></tr>
<tr><td colspan="5">Short description:
This adaptive management scenario aims to restore the artificially maintained mixed Norway spruce forest to the natural vegetation. The potential natural vegetation is understood as the species mixture and stand structure resulting from the local environmental conditions including disturbance regimes and with exclusion of anthropogenic interventions. The strategy is to harvest Norway spruce trees when they reached the production target and to reduce the spruce dominance by applying rather heavy thinning prescriptions that aim to gradually remove the spruce trees out of the forest. With this strategy the remaining spruce timber stock can be used, where at the same time natural regeneration is promoted in the gaps opened by the thinning prescriptions.
To account for minimal management operations such as track maintenance or fellings to safeguard other infrastructure a small proportion of large trees is harvested each decade. Hence, timber production is expected to be very low in the long term, whereas the restoration of the PNV is expected to have a positive effect on biodiversity. The promotion of the PNV benefits forest stability (RI) regarding windthrow and insects and with increased biodiversity the forest will be more capable to adapt (AC) to new environmental conditions.

Note: This conversion regime can be applied to both even-aged and uneven-aged Norway spruce forests (Stand/site type 1 and 2).</td></tr>
</table>

Case study	Black forest, LandClim			
Stand x site type	- Uneven-aged mixed oak forest (converted from even-aged Norway spruce) - Soil type: xxx ; Nutrients: xxx ; Water: low			
Management alternative	**Nr:5** **BAUM**/ AM **System**: Uneven-aged "Combined-objective forestry": Promotion of oak **Selection cuttings intensity (weak, average, heavy):** heavy **Addressed climate change effect**: increased temperatures, drought, risk of drought spells, windthrow and insect mortality **Adaptation strategy (B, RI, AC)**: B, RI, AC **Expected level for addressed objectives (low, average, high)**: Timber production: low-average; biodiversity: high;			
Cutting cycle	10 years			
Threshold basal area for management	--			
Diameter class	**0-12 cm**	**32-48 cm**	**>48 cm**	**>100 cm**
Harvest intensity (HI), in trees %	Douglas fir = 70 Others = 0	Downy oak = 80 Scots pine = 80 Douglas fir = 70 Others = 0	All species = 80	--

Short description:
Once the Norway spruce forest is converted (see even-aged management system Nr: 3) an uneven-aged mixed oak forest is maintained by tending and thinning out Douglas fir, the main competitor. A target diameter harvest is applied to downy oak and scots pine at a production target of 32 cm dgh and to other species at a production target of 48 cm dbh, respectively. Such a mixed oak forest is considered to be resistant to drought as well as other disturbance agents (RI). Due to the promotion of a wide range of species in the conversion phase high biodiversity and therefore adaptive capacity is expected (AC). The timber yield of slow growing oaks is expected to be relatively low.

1. Note: This target diameter harvest regime is intended to be applied after a conversion from Norway spruce to oak forest as described under the even-aged management systems Nr: 3).

2. Note: This conversion regime can be applied to both even-aged and uneven-aged Norway spruce forests (Stand/site type 1 and 2).

Central Black forest case (3a1, stand level)

Case study	Germany, Rastatt/Baden-Baden
Stand type	Spruce – Mixed even aged, with: 60-80% spruce, 20-40% beech, 0-20% fir
Site types	Management is oriented at dominant height and is therefore not site specific
Management alternative	BAUM
Objectives	high quality timber production (dbh > 60 cm) single trees stability carbon sequestration: low biodiversity: moderate
Phase of Development	
- Regeneration	no planting, if more than 1700 seedlings/ha from natural regeneration
- Young	tree height 2m: schematic reduction to 1000-1500 trees/ha tree height 5m: selection of 250 trees/ha without competitors within 3 m release of max. 250 spruces and mixed species in patches
- Medium	pruning: at tree height 12 m: selection of 150 future crop trees and pruning up to 5 m of future crop trees (only on better sites with low wind risk). tree height 15 m: if no pruning before, pruning up to 5 m of 150 future crop trees
- Adult	Final harvest by target diameter (>60 cm dbh), harvest volume per operation about 100-140 m^3, if necessary underplant with beech. Time period between start and final harvest may last more than 40 years

Case study	Germany, Rastatt/Baden-Baden
Stand type	Spruce – Mixed even aged
Site types	Management is oriented at dominant height and is therefore not site specific
Management alternative	Alternative Management addresses climate change effect: drought and wind only applied on high storm risk sites and medium to poor water holding capacity Adaptation strategy: RI, AC
Objectives	high quality timber production (dbh >50 cm) single trees stability carbon sequestration: low biodiversity: low
Phase of Development	
- Regeneration	no planting, if more than 1700 seedlings/ha from natural regeneration
- Young	tree height 2m: schematic reduction to 500-750 trees/ha tree height 5m: selection of 150 trees/ha without competitors within 3 m release of max. 100 spruces and mixed species in patches
- Medium	pruning: at tree height 12 m: selection of 100 future crop trees and pruning up to 5 m of future crop trees (only on better sites with low wind risk). tree height 15 m: if no pruning before, pruning up to 5 m of 100 future crop trees
- Adult	Final harvest by target diameter (>50 cm dbh), harvest volume per operation about 100-200 m^3, beech in understorey only by natural regeneration. Time period between start and final harvest not longer than 40 years

Case study	Germany, Rastatt/Baden-Baden
Stand type	Mixed Deciduous (mainly ash, maple, cherry, chestnut and others)
Site types	Management is oriented at dominant height and is therefore not site specific
Management alternative	BAUM
Objectives	high quality timber production (dbh > 50 cm) carbon sequestration: low biodiversity: high
Phase of Development	
- Regeneration	Planting only if no sufficient natural regeneration. Planting (under light canopy) with 1.0 to 2.5 x 1.0 m spacing (not more than 1000 trees/ha) of 2 year old plants
- Young	Tree height 2m: forming of groups of the same species by schematic reduction. But no reduction between the groups. Pruning only with cherry and nuts.
- Medium	Selection of 60-80 future crop trees at a dominant height of 25% of the expected total height. Removal of competitors of the future crop trees, such that 25% of crown length will remain. Thinning interval 3-10 years, not more than 60 m^3 per thinning
- Adult	Target diameter harvest, building of regeneration groups. Target diameter 40 cm with lower quality, 50 cm with higher quality. If necessary underplant in groups.

Case study	Germany, Rastatt/Baden-Baden
Stand type	Mixed Deciduous (cherry, chestnut, nuts)
Site types	Management is oriented at dominant height and is therefore not site specific
Management alternative	Alternative Management addresses climate change effect: drought, wind only applied on sites with medium – poor water holding capacity and/or with high storm risk Adaptation strategy: AC
Objectives	high quality timber production (dbh >40 cm) and as by-product energy wood carbon sequestration: low biodiversity: medium - high
Phase of Development	
- Regeneration	Planting only if no sufficient natural regeneration. Planting (under light canopy) with 1.0 to 2.5 x 1.0 m spacing (not more than 500 trees/ha) of 2 year old plants
- Young	Tree height 2m: forming of groups of the same species. Prefer chestnut, reduce maple. Reduction between the groups, low quality as energy wood extraction. Pruning only with cherry and nuts.
- Medium	Selection of 50 future crop trees at a dominant height of 25% of the expected total height. Removal of competitors andreduction of low quality tree, such that 25% of crown length of the future crop trees will remain. Thinning interval 3-10 years, not more than 80 m^3 per thinning
- Adult	Target diameter harvest, building of regeneration groups. Target diameter 30 cm with lower quality, 40 cm with higher quality. If necessary underplant in groups.

Case study	Germany, Rastatt/Baden-Baden
Stand type	Fir – Mixed, mainly uneven aged with: Fir (30-60%), spruce (20-60%), beech (10-50%), possibly with pine and douglas-fir (0-30%)
Site types	Management is oriented at dominant height and is therefore not site specific
Management alternative	BAUM
Objectives	high quality timber production (dbh > 60 cm) maintain and enhance fir carbon sequestration: medium (maintain high continuous stocking of 350-550 m^3/ha) biodiversity (structural): high, biodiversity (species): medium
Phase of Development	
- Regeneration	natural regeneration under continuous-cover forest
- Young	use of continuous cover for differentiation of young trees (height of 2 m)
- Medium	select 100-150 future crop trees, pruning stepwise up to 10 m (douglas-fir 15 m) reduce competitors of future crop trees thinning interval: 3-10 years, maximum of 80 m^3 per thinning operation
- Adult	Final harvest by target diameter (>60 cm dbh), harvesting level is in the range of growth. Not more than 80 m^3 per harvesting operation

Case study	Germany, Rastatt/Baden-Baden
Stand type	Fir – Mixed, mainly uneven aged with: Fir (>60%), spruce (0-20%), beech (0-20%), pine and douglas-fir (0-50%)
Site types	Management is oriented at dominant height and is therefore not site specific
Management alternative	Alternative Management addresses climate change effect: drought Adaptation strategy: AC
Objectives	high quality timber production (dbh >50 cm) maintain and enhance fir, douglas fir and pine reduce beech and spruce carbon sequestration: medium (maintain high continuous stocking of 250-400 m^3/ha) biodiversity (structural): high, biodiversity (species): medium
Phase of Development	
- Regeneration	natural regeneration under continuous-cover forest
- Young	use of continuous cover for differentiation of young trees (height of 2 m), further schematic reduction of beech and spruce, building of groups for fir, douglas fir and pine (together > 70%)
- Medium	select 50-75 future crop trees, pruning stepwise up to 10 m (douglas-fir 15 m) reduce competitors of future crop trees and trees between thinning interval: 3-10 years, maximum of 100 m^3 per thinning operation
- Adult	Final harvest by target diameter (>50 cm dbh), harvesting level is in the range of growth. Not more than 100 m^3 per harvesting operation. Total standing volume should not exceed 400 m^3/ha

Case study	Germany, Rastatt/Baden-Baden
Stand type	Mixed - extensive, mainly uneven aged with, trees species: locally adapted
Site types	basically on poor sites (low SI)
Management alternative	BAUM Alternative: NO
Objectives	biodiversity: high carbon sequestration: high timber production: low
Phase of Development	no phases of development, basically no harvesting only to maintain recreational status of the forest For the protection against erosion planting is possible

Case study	Germany, Rastatt/Baden-Baden
Stand type	Douglas – Mixed even aged, with: 50-80% douglas fir, 20-50% beech
Site types	Management is oriented at dominant height and is therefore not site specific
Management alternative	BAUM
Objectives	high quality timber production (dbh: 80-120 cm) carbon sequestration: medium biodiversity: moderate
Phase of Development	
- Regeneration	planting of douglas fir 4-6 m x 2m, maximum of 1,200 trees/ha, up to 5,000 – 10,000 beech trees/ha
- Young	tree height 2m: schematic reduction to 800 trees/ha tree height 5m: selection of 250 trees/ha
- Medium	pruning: at tree height 12 m: selection of 100-200 future crop trees and pruning up to 6 m of future crop trees. Reduction of competitors of future crop trees. tree height 15-20m: reduction of competitors of future crop trees (1-3 trees per thinning), interval: 5-10 years, maximum cut of 100 m^3/ha. Forming of beech groups, 60-80 future crop trees at a tree height of 17 m. further pruning of douglas future crop trees up to 10 – 15m.
- Adult	Reduce low quality douglas fir Start of target diameter harvest (dbh > 80 cm) Formation of beech groups with better quality (knotless)

Case study	Germany, Rastatt/Baden-Baden
Stand type	Douglas – Mixed even aged, with: 50-80% douglas fir, 20-50% other broadleaved trees (chestnut, cherry, ash)
Site types	Management is oriented at dominant height and is therefore not site specific
Management alternative	Alternative Management addresses climate change effect: drought Adaptation strategy: AC
Objectives	High quality timber production (dbh: 60-80 cm) Carbon sequestration: medium Biodiversity: moderate
Phase of Development	
- Regeneration	Planting of douglas fir 4-6 m x 2m, maximum of 1,200 trees/ha, other broadleaved (chestnut, ash) basically from natural regeneration, cherries planted group - wise
- Young	Tree height 2m: schematic reduction to 600 trees/ha tree height 5m: selection of 200 trees/ha
- Medium	Pruning: at tree height 12 m: selection of 50-100 future crop trees and pruning up to 6 m of future crop trees. Reduction of competitors of future crop trees. Reduction of low quality trees in between for energy wood. Tree height 15-20m: reduction of competitors of future crop trees (2-3 trees per thinning), interval: 5-10 years, maximum cut of 120 m^3/ha. Forming of groups of other broadleaved trees, with max. 30 future crop trees at a tree height of 17 m. further pruning of douglas future crop trees up to 10 m.
- Adult	Reduce low quality douglas fir and trees between competitors (100-200 m^3 per harvesting operation) Start of target diameter harvest (dbh >60 cm) Formation of groups of other broadleaved trees with better quality (knotless)

Case study	Germany, Rastatt/Baden-Baden
Stand type	Beech – Mixed even aged, with: 60-80% beech, 10-40% other broadleaved trees, 0-20% other conifers
Site types	Management is oriented at dominant height and is therefore not site specific
Management alternative	BAUM
Objectives	high quality timber production (dbh > 60 cm) carbon sequestration: low biodiversity: moderate
Phase of Development	
- Regeneration	Only if no sufficient natural regeneration. Planting (under light canopy) with 1.0 to 2.5 x 1.0 m spacing (at least 5.000/ha) of 2 year old plants; support of natural regeneration or planting from mixed species (other broadleaves or conifers) (~20%) in groups
- Young	Selection of 60 – 80 future crop trees, forming of crowns, such that knotless free stem ~ 50% of total expected height and crown length is ~ 25% of total expected height Thinning interval: 4-10 years. Maximum cut of $80m^3$/ha. Formation of groups for other broadleaved trees.
- Medium	preparation of target diameter harvest by careful reduction of 1-3 competitors of the future crop trees. Maximum cut of $80m^3$/ha.
- Adult	Single tree target diameter harvest: lower qualities 40 cm dbh, better qualities > 60 cm dbh. Initiation of natural regeneration. End of final harvesting latest at +/-140 year rotation age.

Case study	Germany, Rastatt/Baden-Baden
Stand type	Beech – Mixed even aged, with: 60-80% beech, 10-40% other broadleaved trees (only cherries, chestnut, nuts), conifers 0-40%: only pine or douglas fir
Site types	Management is oriented at dominant height and is therefore not site specific
Management alternative	Alternative Management addresses climate change effect: drought Adaptation strategy: AC, RI
Objectives	high quality timber production (dbh >40 cm) carbon sequestration: low biodiversity: moderate
Phase of Development	
- Regeneration	Only if no sufficient natural regeneration. Planting (under light canopy) with 1.0 to 2.5 x 1.0 m spacing (at least 3.000/ha) of 2 year old plants; support of natural regeneration or planting from mixed species (cherries, chestnut, nuts, pine, douglas fir) (~20%) in groups
- Young	Selection of 40 - 60 future crop trees, forming of crowns, such that knotless free stem ~ 50% of total expected height and crown length is ~ 25% of total expected height Thinning interval: 4-10 years. Maximum cut of 120 m^3/ha. Formation of groups for other broadleaved trees. Reduction of low quality trees also in between.
- Medium	preparation of target diameter harvest by careful reduction of 1-3 competitors of the future crop trees and reduction of low quality trees also in between. Maximum cut of 120 m^3/ha. Interval: 4-8 years
- Adult	Single tree target diameter harvest: lower qualities 30 cm dbh, better qualities >40 cm dbh. Initiation of natural regeneration. End of final harvesting latest at +/-120 year rotation age.

Central Alpine case (3b1)

- Although our forests are uneven-aged we used the even-aged template, as management differs strongly from the selection cutting system which the uneven-aged template is aiming at.

Stand x site type 1: Uneven-aged pure Norway spruce stands, site 1 (soil type: Rendzina, nutrients: average, water: average)

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged pure Norway spruce stands - Soil type: Rendzina; Nutrients[8] (poor, average, high): average; Water[1] (low, average, high): average	
Management alternative	**No.:** 1 **BAUM/AM:** BAUM1 **System**: **Regeneration:** natural **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** none **Addressed climate change effect**: N/A **Adaptation strategy (B, RI, AC)**: N/A **Expected level for addressed objectives (low, average, high)**: protection against erosion, avalanches, and rock fall (low), biodiversity (low)	
Phase of development	**Process**	**Description**
Regeneration	None	
Young	None	
Medium	None	
Adult	None	
Short description: BAUM schedule for anuneven-aged pure Norway spruce forest in very steep terrain. Due to the terrain no management actions are carried out. Average productivity, average nutrient supply and average water holding capacity and availability. The objectives are protection against erosion, avalanches, landslides and rock fall as well as biodiversity.		

[8] "Nutrients" refers to (content x availability); "Water" refers to (holding capacity x availability)

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged pure Norway spruce stands - Soil type: Rendzina; Nutrients (poor, average, high): average; Water(low, average, high): average	
Management alternative	**No.:** 2 **BAUM/AM:** BAUM2 **System**: Uneven-aged; cable crane slit-cut **Regeneration:** natural **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 150-250 years depending on management intensity **Addressed climate change effect**: N/A **Adaptation strategy (B, RI, AC)**: N/A **Expected level for addressed objectives (low, average, high)**: timber production (average), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce
Young	Tending	None
Medium	Thinning	None
Adult	Slit cut (regeneration cut)	Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: BAUM schedule for anuneven-aged pure Norway spruce in steep terrain (harvesting bound to skyline systems). Average productivity, average nutrient supply and average water holding capacity and availability. The main objective is protection against erosion, avalanches and landslides. Timber production, protection against rock fall, biodiversity, provision of drinking water and are also considered.		

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged pure Norway spruce stands - Soil type: Rendzina; Nutrients (poor, average, high): average; Water(low, average, high): average	
Management alternative	**No.:** 3 **BAUM/AM:** AM **System**: Uneven-aged; cable crane slit-cut **Regeneration:** natural/ artificial **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 150-250 years depending on management intensity **Addressed climate change effect**: intensified bark beetle disturbances **Adaptation strategy (B, RI, AC)**: RI, AC **Expected level for addressed objectives (low, average, high)**: timber production (average), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce
	Artificial regeneration	Of European larch; planted in patches (ca. 17.5 m diameter); 25 plants per patch (2 x 2 m spacing); 25 % of the slit cut are covered by larch patches
Young	Tending	None
Medium	Thinning 1	None
Adult	Slit cut (regeneration cut)	Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: Disturbances by *Ips typographus* are expected to increase under climate change. Therefore the large share of Norway spruce will be decreased by the introduction of European larch (RI). A broader species set will increase the AC.		

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged pure Norway spruce stands - Soil type: Rendzina; Nutrients (poor, average, high): average; Water(low, average, high): average	
Management alternative	**No.:** 4 **BAUM/AM:** AM **System**: Uneven-aged; cable crane slit-cut **Regeneration:** natural/ artificial **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 150-250 years depending on management intensity **Addressed climate change effect**: intensified bark beetle disturbances **Adaptation strategy (B, RI, AC)**: RI, AC **Expected level for addressed objectives (low, average, high)**: timber production (average), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce
	Artificial regeneration	Of European larch; planted in patches (ca. 17.5 m diameter); 25 plants per patch (2 x 2 m spacing); 25 % of the slit cut are covered by larch patches
	Game management	Ungulate game species (i.e. chamois, roe deer, and red deer) densities are reduced significantly to enhance regeneration of spruce, larch and other species where seeds are available (e.g. rowan, sycamore maple)
Young	Tending	None
Medium	Thinning	None
Adult	Slit cut (regeneration cut)	Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: Disturbances by *Ips typographus* are expected to increase under climate change. Therefore, the artificial regeneration of larch and the game management will decrease the large share of Norway spruce in the regeneration in favour of larch and other species (RI). A broader species set will increase the AC.		

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged pure Norway spruce stands - Soil type: Rendzina; Nutrients (poor, average, high): average; Water(low, average, high): average	
Management alternative	**No.:** 5 **BAUM/AM:** AM **System**: Uneven-aged; modified cable crane slit-cuts **Regeneration:** natural **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 30-60 years **Addressed climate change effect**: intensified bark beetle disturbances, NPP change **Adaptation strategy (B, RI, AC)**: RI, AC, B **Expected level for addressed objectives (low, average, high)**: timber production (average), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce
	Game management	Ungulate game species (i.e. chamois, roe deer, and red deer) densities are reduced significantly to enhance regeneration of spruce and other species where seeds are available (e.g. rowan, sycamore maple)
Young	Tending	None
Medium	Thinning	None
Adult	Slit cuts (regeneration cuts)	The shape of the slit cut is modified. The skyline track is cut diagonal to the slope. From this track slit cuts are cut parallel to the contour lines. These slits have a size of ca. 30-40 m in length and a width of ca. 15-20 m. They are placed every 40-60 m alternating on the left and right hand side of the skyline track. Within the slit cuts everything > 25 cm DBH is cut by motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: Disturbances by *Ips typographus* are expected to increase under climate change. More frequent and larger management actions will reduce the share of over-mature stands (RI) and make better use of possibly increasing growth rates (B). Additionally an adapted game management will decrease the long regeneration time-spans as well as enhance the regeneration of all tree species. A broader species set will increase the AC.		

Stand x site type 2: Uneven-aged pure Norway spruce stands, site 2 (soil type: Ranker, nutrients: average, water: high)

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged pure Norway spruce stands - Soil type: Ranker; Nutrients (poor, average, high): average; Water(low, average, high): high	
Management alternative	**No.:** 1 **BAUM/AM:** BAUM1 **System**: **Regeneration:** natural **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** none **Addressed climate change effect**: N/A **Adaptation strategy (B, RI, AC)**: N/A **Expected level for addressed objectives (low, average, high)**: protection against erosion, avalanches, and rock fall (low), biodiversity (low)	
Phase of development	**Process**	**Description**
Regeneration	None	
Young	None	
Medium	None	
Adult	None	
Short description: BAUM schedule for anuneven-aged pure Norway spruce forest in very steep terrain. Due to the terrain no management actions are carried out. Average productivity, average nutrient supply and high water holding capacity and availability. The objectives are protection against erosion, avalanches, landslides and rock fall as well as biodiversity.		

<table>
<tr><td>Case study</td><td colspan="2">3b1 Temperate central alpine - Montafon</td></tr>
<tr><td>Stand x site type</td><td colspan="2">- Uneven-aged pure Norway spruce stands
- Soil type: Ranker; Nutrients (poor, average, high): average; Water(low, average, high): high</td></tr>
<tr><td>Management alternative</td><td colspan="2">No.: 2
BAUM/AM: BAUM2
System: Uneven-aged; cable crane slit-cut
Regeneration: natural
Thinning type (below, above): none
Thinning intensity (weak, average, heavy): none
Entry interval: 150-250 years depending on management intensity
Addressed climate change effect: N/A
Adaptation strategy (B, RI, AC): N/A
Expected level for addressed objectives (low, average, high): timber production (average), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)</td></tr>
<tr><td>Phase of development</td><td>Process</td><td>Description</td></tr>
<tr><td>Regeneration</td><td>Natural regeneration</td><td>Of spruce; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce</td></tr>
<tr><td>Young</td><td>Tending</td><td>None</td></tr>
<tr><td>Medium</td><td>Thinning</td><td>None</td></tr>
<tr><td>Adult</td><td>Slit cut (regeneration cut)</td><td>Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.</td></tr>
<tr><td colspan="3">Short description: BAUM schedule for anuneven-aged pure Norway spruce in steep terrain (harvesting bound to skyline systems). Average productivity, average nutrient supply and high water holding capacity and availability. The main objective is protection against erosion, avalanches and landslides. Timber production, protection against rock fall, biodiversity, provision of drinking water and are also considered.</td></tr>
</table>

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged pure Norway spruce stands - Soil type: Ranker; Nutrients (poor, average, high): average; Water(low, average, high): high	
Management alternative	**No.:** 3 **BAUM/AM:** AM **System**: Uneven-aged; cable crane slit-cut **Regeneration:** natural/ artificial **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 150-250 years depending on management intensity **Addressed climate change effect**: intensified bark beetle disturbances **Adaptation strategy (B, RI, AC)**: RI, AC **Expected level for addressed objectives (low, average, high)**: timber production (average), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce
	Artificial regeneration	Of European larch; planted in patches (ca. 17.5 m diameter); 25 plants per patch (2 x 2 m spacing); 25 % of the slit cut are covered by larch patches
Young	Tending	None
Medium	Thinning 1	None
Adult	Slit cut (regeneration cut)	Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: Disturbances by *Ips typographus* are expected to increase under climate change. Therefore the large share of Norway spruce will be decreased by the introduction of European larch (RI). A broader species set will increase the AC.		

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged pure Norway spruce stands - Soil type: Ranker; Nutrients (poor, average, high): average; Water(low, average, high): high	
Management alternative	**No.:** 4 **BAUM/AM:** AM **System**: Uneven-aged; cable crane slit-cut **Regeneration:** natural/ artificial **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 150-250 years depending on management intensity **Addressed climate change effect**: intensified bark beetle disturbances **Adaptation strategy (B, RI, AC)**: RI, AC **Expected level for addressed objectives (low, average, high)**: timber production (average), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce
	Artificial regeneration	Of European larch; planted in patches (ca. 17.5 m diameter); 25 plants per patch (2 x 2 m spacing); 25 % of the slit cut are covered by larch patches
	Game management	Ungulate game species (i.e. chamois, roe deer, and red deer) densities are reduced significantly to enhance regeneration of spruce, larch and other species where seeds are available (e.g. rowan, sycamore maple)
Young	Tending	None
Medium	Thinning	None
Adult	Slit cut (regeneration cut)	Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: Disturbances by *Ips typographus* are expected to increase under climate change. Therefore, the artificial regeneration of larch and the game management will decrease the large share of Norway spruce in the regeneration in favour of larch and other species (RI). A broader species set will increase the AC.		

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged pure Norway spruce stands - Soil type: Ranker; Nutrients (poor, average, high): average; Water(low, average, high): high	
Management alternative	**No.:** 5 **BAUM/AM:** AM **System**: Uneven-aged; modified cable crane slit-cuts **Regeneration:** natural **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 30-60 years **Addressed climate change effect**: intensified bark beetle disturbances, NPP change **Adaptation strategy (B, RI, AC)**: RI, AC, B **Expected level for addressed objectives (low, average, high)**: timber production (average), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce
	Game management	Ungulate game species (i.e. chamois, roe deer, and red deer) densities are reduced significantly to enhance regeneration of spruce and other species where seeds are available (e.g. rowan, sycamore maple)
Young	Tending	None
Medium	Thinning	None
Adult	Slit cuts (regeneration cuts)	The shape of the slit cut is modified. The skyline track is cut diagonal to the slope. From this track slit cuts are cut parallel to the contour lines. These slits have a size of ca. 30-40 m in length and a width of ca. 15-20 m. They are placed every 40-60 m alternating on the left and right hand side of the skyline track. Within the slit cuts everything > 25 cm DBH is cut by motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: Disturbances by *Ips typographus* are expected to increase under climate change. More frequent and larger management actions will reduce the share of over-mature stands (RI) and make better use of possibly increasing growth rates (B). Additionally an adapted game management will decrease the long regeneration time-spans as well as enhance the regeneration of all tree species. A broader species set will increase the AC.		

Stand x site type 3: Uneven-aged pure Norway spruce stands, site 3 (soil type: Ranker, nutrients: poor, water: average)

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged pure Norway spruce stands - Soil type: Ranker; Nutrients (poor, average, high): poor; Water(low, average, high): average	
Management alternative	**No.:** 1 **BAUM/AM:** BAUM1 **System**: **Regeneration:** natural **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** none **Addressed climate change effect**: N/A **Adaptation strategy (B, RI, AC)**: N/A **Expected level for addressed objectives (low, average, high)**: protection against erosion, avalanches, and rock fall (low), biodiversity (low)	
Phase of development	**Process**	**Description**
Regeneration	None	
Young	None	
Medium	None	
Adult	None	
Short description: BAUM schedule for anuneven-aged pure Norway spruce forest in very steep terrain. Due to the terrain no management actions are carried out. Low to average productivity, poor nutrient supply and average water holding capacity and availability. The objectives are protection against erosion, avalanches, landslides and rock fall as well as biodiversity.		

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged pure Norway spruce stands - Soil type: Ranker; Nutrients (poor, average, high): poor; Water(low, average, high): average	
Management alternative	**No.:** 2 **BAUM/AM:** BAUM2 **System**: Uneven-aged; cable crane slit-cut **Regeneration:** natural **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 150-250 years depending on management intensity **Addressed climate change effect**: N/A **Adaptation strategy (B, RI, AC)**: N/A **Expected level for addressed objectives (low, average, high)**: timber production (low), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce
Young	Tending	None
Medium	Thinning	None
Adult	Slit cut (regeneration cut)	Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: BAUM schedule for anuneven-aged pure Norway spruce in steep terrain (harvesting bound to skyline systems). Low to average productivity, poor nutrient supply and average water holding capacity and availability. The main objective is protection against erosion, avalanches and landslides. Timber production, protection against rock fall, biodiversity, provision of drinking water and are also considered.		

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged pure Norway spruce stands - Soil type: Ranker; Nutrients (poor, average, high): poor; Water(low, average, high): average	
Management alternative	**No.:** 3 **BAUM/AM:** AM **System**: Uneven-aged; cable crane slit-cut **Regeneration:** natural/ artificial **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 150-250 years depending on management intensity **Addressed climate change effect**: intensified bark beetle disturbances **Adaptation strategy (B, RI, AC)**: RI, AC **Expected level for addressed objectives (low, average, high)**: timber production (low), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce
	Artificial regeneration	Of European larch; planted in patches (ca. 17.5 m diameter); 25 plants per patch (2 x 2 m spacing); 25 % of the slit cut are covered by larch patches
Young	Tending	None
Medium	Thinning 1	None
Adult	Slit cut (regeneration cut)	Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: Disturbances by *Ips typographus* are expected to increase under climate change. Therefore the large share of Norway spruce will be decreased by the introduction of European larch (RI). A broader species set will increase the AC.		

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged pure Norway spruce stands - Soil type: Ranker; Nutrients (poor, average, high): poor; Water(low, average, high): average	
Management alternative	**No.:** 4 **BAUM/AM:** AM **System**: Uneven-aged; cable crane slit-cut **Regeneration:** natural/ artificial **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 150-250 years depending on management intensity **Addressed climate change effect**: intensified bark beetle disturbances **Adaptation strategy (B, RI, AC)**: RI, AC **Expected level for addressed objectives (low, average, high)**: timber production (low), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce
	Artificial regeneration	Of European larch; planted in patches (ca. 17.5 m diameter); 25 plants per patch (2 x 2 m spacing); 25 % of the slit cut are covered by larch patches
	Game management	Ungulate game species (i.e. chamois, roe deer, and red deer) densities are reduced significantly to enhance regeneration of spruce, larch and other species where seeds are available (e.g. rowan, sycamore maple)
Young	Tending	None
Medium	Thinning	None
Adult	Slit cut (regeneration cut)	Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: Disturbances by *Ips typographus* are expected to increase under climate change. Therefore, the artificial regeneration of larch and the game management will decrease the large share of Norway spruce in the regeneration in favour of larch and other species (RI). A broader species set will increase the AC.		

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged pure Norway spruce stands - Soil type: Ranker; Nutrients (poor, average, high): poor; Water(low, average, high): average	
Management alternative	**No.:** 5 **BAUM/AM:** AM **System**: Uneven-aged; modified cable crane slit-cuts **Regeneration:** natural **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 30-60 years **Addressed climate change effect**: intensified bark beetle disturbances, NPP change **Adaptation strategy (B, RI, AC)**: RI, AC, B **Expected level for addressed objectives (low, average, high)**: timber production (low), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce
	Game management	Ungulate game species (i.e. chamois, roe deer, and red deer) densities are reduced significantly to enhance regeneration of spruce and other species where seeds are available (e.g. rowan, sycamore maple)
Young	Tending	None
Medium	Thinning	None
Adult	Slit cuts (regeneration cuts)	The shape of the slit cut is modified. The skyline track is cut diagonal to the slope. From this track slit cuts are cut parallel to the contour lines. These slits have a size of ca. 30-40 m in length and a width of ca. 15-20 m. They are placed every 40-60 m alternating on the left and right hand side of the skyline track. Within the slit cuts everything > 25 cm DBH is cut by motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.

Short description: Disturbances by *Ips typographus* are expected to increase under climate change. More frequent and larger management actions will reduce the share of over-mature stands (RI) and make better use of possibly increasing growth rates (B). Additionally an adapted game management will decrease the long regeneration time-spans as well as enhance the regeneration of all tree species. A broader species set will increase the AC.

Stand x site type 4: Uneven-aged pure Norway spruce stands, site 4 (soil type: Cambisol, nutrients: high, water: high)

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged pure Norway spruce stands - Soil type: Cambisol; Nutrients (poor, average, high): high; Water(low, average, high): high	
Management alternative	**No.:** 2 **BAUM/AM:** BAUM2 **System**: Uneven-aged; cable crane slit-cut **Regeneration:** natural **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 150-250 years depending on management intensity **Addressed climate change effect**: N/A **Adaptation strategy (B, RI, AC)**: N/A **Expected level for addressed objectives (low, average, high)**: timber production (high), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce
Young	Tending	None
Medium	Thinning	None
Adult	Slit cut (regeneration cut)	Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: BAUM schedule for anuneven-aged pure Norway spruce in steep terrain (harvesting bound to skyline systems). Average to high productivity, mostly soils with high nutrient supply and high water holding capacity and availability. The main objective is timber production and protection against erosion, avalanches and landslides. Protection against rock fall, biodiversity, provision of drinking water and are also considered.		

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged pure Norway spruce stands - Soil type: Cambisol; Nutrients (poor, average, high): high; Water(low, average, high): high	
Management alternative	**No.:** 3 **BAUM/AM:** AM **System**: Uneven-aged; cable crane slit-cut **Regeneration:** natural/ artificial **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 150-250 years depending on management intensity **Addressed climate change effect**: intensified bark beetle disturbances **Adaptation strategy (B, RI, AC)**: RI, AC **Expected level for addressed objectives (low, average, high)**: timber production (high), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce
	Artificial regeneration	Of European larch; planted in patches (ca. 17.5 m diameter); 25 plants per patch (2 x 2 m spacing); 25 % of the slit cut are covered by larch patches
Young	Tending	None
Medium	Thinning 1	None
Adult	Slit cut (regeneration cut)	Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: Disturbances by *Ips typographus* are expected to increase under climate change. Therefore the large share of Norway spruce will be decreased by the introduction of European larch (RI). A broader species set will increase the AC.		

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged pure Norway spruce stands - Soil type: Cambisol; Nutrients (poor, average, high): high; Water(low, average, high): high	
Management alternative	**No.:** 4 **BAUM/AM:** AM **System**: Uneven-aged; cable crane slit-cut **Regeneration:** natural/ artificial **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 150-250 years depending on management intensity **Addressed climate change effect**: intensified bark beetle disturbances **Adaptation strategy (B, RI, AC)**: RI, AC **Expected level for addressed objectives (low, average, high)**: timber production (high), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce
	Artificial regeneration	Of European larch; planted in patches (ca. 17.5 m diameter); 25 plants per patch (2 x 2 m spacing); 25 % of the slit cut are covered by larch patches
	Game management	Ungulate game species (i.e. chamois, roe deer, and red deer) densities are reduced significantly to enhance regeneration of spruce, larch and other species where seeds are available (e.g. rowan, sycamore maple)
Young	Tending	None
Medium	Thinning	None
Adult	Slit cut (regeneration cut)	Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: Disturbances by *Ips typographus* are expected to increase under climate change. Therefore, the artificial regeneration of larch and the game management will decrease the large share of Norway spruce in the regeneration in favour of larch and other species (RI). A broader species set will increase the AC.		

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged pure Norway spruce stands - Soil type: Cambisol; Nutrients (poor, average, high): high; Water(low, average, high): high	
Management alternative	**No.:** 5 **BAUM/AM:** AM **System**: Uneven-aged; modified cable crane slit-cuts **Regeneration:** natural **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 30-60 years **Addressed climate change effect**: intensified bark beetle disturbances, NPP change **Adaptation strategy (B, RI, AC)**: RI, AC, B **Expected level for addressed objectives (low, average, high)**: timber production (high), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce
	Game management	Ungulate game species (i.e. chamois, roe deer, and red deer) densities are reduced significantly to enhance regeneration of spruce and other species where seeds are available (e.g. rowan, sycamore maple)
Young	Tending	None
Medium	Thinning	None
Adult	Slit cuts (regeneration cuts)	The shape of the slit cut is modified. The skyline track is cut diagonal to the slope. From this track slit cuts are cut parallel to the contour lines. These slits have a size of ca. 30-40 m in length and a width of ca. 15-20 m. They are placed every 40-60 m alternating on the left and right hand side of the skyline track. Within the slit cuts everything > 25 cm DBH is cut by motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: Disturbances by *Ips typographus* are expected to increase under climate change. More frequent and larger management actions will reduce the share of over-mature stands (RI) and make better use of possibly increasing growth rates (B). Additionally an adapted game management will decrease the long regeneration time-spans as well as enhance the regeneration of all tree species. A broader species set will increase the AC.		

Stand x site type 5: Uneven-aged pure Norway spruce stands, site 5 (soil type: poor Cambisol, nutrients: average, water: high)

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged pure Norway spruce stands - Soil type: poor Cambisol; Nutrients (poor, average, high): average; Water(low, average, high): high	
Management alternative	**No.:** 2 **BAUM/AM:** BAUM2 **System**: Uneven-aged; cable crane slit-cut **Regeneration:** natural **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 150-250 years depending on management intensity **Addressed climate change effect**: N/A **Adaptation strategy (B, RI, AC)**: N/A **Expected level for addressed objectives (low, average, high)**: timber production (high), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce
Young	Tending	None
Medium	Thinning	None
Adult	Slit cut (regeneration cut)	Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: BAUM schedule for anuneven-aged pure Norway spruce in steep terrain (harvesting bound to skyline systems). Average to high productivity, mostly soils with average nutrient supply and high water holding capacity and availability. The main objective is timber production and protection against erosion, avalanches and landslides. Protection against rock fall, biodiversity, provision of drinking water and are also considered.		

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged pure Norway spruce stands - Soil type: poor Cambisol; Nutrients (poor, average, high): average; Water(low, average, high): high	
Management alternative	**No.:** 3 **BAUM/AM:** AM **System**: Uneven-aged; cable crane slit-cut **Regeneration:** natural/ artificial **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 150-250 years depending on management intensity **Addressed climate change effect**: intensified bark beetle disturbances **Adaptation strategy (B, RI, AC)**: RI, AC **Expected level for addressed objectives (low, average, high)**: timber production (high), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce
	Artificial regeneration	Of European larch; planted in patches (ca. 17.5 m diameter); 25 plants per patch (2 x 2 m spacing); 25 % of the slit cut are covered by larch patches
Young	Tending	None
Medium	Thinning 1	None
Adult	Slit cut (regeneration cut)	Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: Disturbances by *Ips typographus* are expected to increase under climate change. Therefore the large share of Norway spruce will be decreased by the introduction of European larch (RI). A broader species set will increase the AC.		

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged pure Norway spruce stands - Soil type: poor Cambisol; Nutrients (poor, average, high): average; Water(low, average, high): high	
Management alternative	**No.:** 4 **BAUM/AM:** AM **System**: Uneven-aged; cable crane slit-cut **Regeneration:** natural/ artificial **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 150-250 years depending on management intensity **Addressed climate change effect**: intensified bark beetle disturbances **Adaptation strategy (B, RI, AC)**: RI, AC **Expected level for addressed objectives (low, average, high)**: timber production (high), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce
	Artificial regeneration	Of European larch; planted in patches (ca. 17.5 m diameter); 25 plants per patch (2 x 2 m spacing); 25 % of the slit cut are covered by larch patches
	Game management	Ungulate game species (i.e. chamois, roe deer, and red deer) densities are reduced significantly to enhance regeneration of spruce, larch and other species where seeds are available (e.g. rowan, sycamore maple)
Young	Tending	None
Medium	Thinning	None
Adult	Slit cut (regeneration cut)	Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: Disturbances by *Ips typographus* are expected to increase under climate change. Therefore, the artificial regeneration of larch and the game management will decrease the large share of Norway spruce in the regeneration in favour of larch and other species (RI). A broader species set will increase the AC.		

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged pure Norway spruce stands - Soil type: poor Cambisol; Nutrients (poor, average, high): average; Water(low, average, high): high	
Management alternative	**No.:** 5 **BAUM/AM:** AM **System**: Uneven-aged; modified cable crane slit-cuts **Regeneration:** natural **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 30-60 years **Addressed climate change effect**: intensified bark beetle disturbances, NPP change **Adaptation strategy (B, RI, AC)**: RI, AC, B **Expected level for addressed objectives (low, average, high)**: timber production (high), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce
	Game management	Ungulate game species (i.e. chamois, roe deer, and red deer) densities are reduced significantly to enhance regeneration of spruce and other species where seeds are available (e.g. rowan, sycamore maple)
Young	Tending	None
Medium	Thinning	None
Adult	Slit cuts (regeneration cuts)	The shape of the slit cut is modified. The skyline track is cut diagonal to the slope. From this track slit cuts are cut parallel to the contour lines. These slits have a size of ca. 30-40 m in length and a width of ca. 15-20 m. They are placed every 40-60 m alternating on the left and right hand side of the skyline track. Within the slit cuts everything > 25 cm DBH is cut by motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: Disturbances by *Ips typographus* are expected to increase under climate change. More frequent and larger management actions will reduce the share of over-mature stands (RI) and make better use of possibly increasing growth rates (B). Additionally an adapted game management will decrease the long regeneration time-spans as well as enhance the regeneration of all tree species. A broader species set will increase the AC.		

Stand x site type 6: Uneven-aged pure Norway spruce stands, site 6 (soil type: (Semi)podzol, nutrients: high, water: high)

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged pure Norway spruce stands - Soil type: (Semi)podzol; Nutrients (poor, average, high): high; Water(low, average, high): high	
Management alternative	**No.:** 2 **BAUM/AM:** BAUM2 **System**: Uneven-aged; cable crane slit-cut **Regeneration:** natural **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 150-250 years depending on management intensity **Addressed climate change effect**: N/A **Adaptation strategy (B, RI, AC)**: N/A **Expected level for addressed objectives (low, average, high)**: timber production (high), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce
Young	Tending	None
Medium	Thinning	None
Adult	Slit cut (regeneration cut)	Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: BAUM schedule for anuneven-aged pure Norway spruce in steep terrain (harvesting bound to skyline systems). Average to high productivity, mostly soils with high nutrient supply and high water holding capacity and availability. The main objective is timber production and protection against erosion, avalanches and landslides. Protection against rock fall, biodiversity, provision of drinking water and are also considered.		

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged pure Norway spruce stands - Soil type: (Semi)podzol; Nutrients (poor, average, high): high; Water(low, average, high): high	
Management alternative	**No.:** 3 **BAUM/AM:** AM **System**: Uneven-aged; cable crane slit-cut **Regeneration:** natural/ artificial **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 150-250 years depending on management intensity **Addressed climate change effect**: intensified bark beetle disturbances **Adaptation strategy (B, RI, AC)**: RI, AC **Expected level for addressed objectives (low, average, high)**: timber production (high), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce
	Artificial regeneration	Of European larch; planted in patches (ca. 17.5 m diameter); 25 plants per patch (2 x 2 m spacing); 25 % of the slit cut are covered by larch patches
Young	Tending	None
Medium	Thinning 1	None
Adult	Slit cut (regeneration cut)	Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: Disturbances by *Ips typographus* are expected to increase under climate change. Therefore the large share of Norway spruce will be decreased by the introduction of European larch (RI). A broader species set will increase the AC.		

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged pure Norway spruce stands - Soil type: (Semi)podzol; Nutrients (poor, average, high): high; Water(low, average, high): high	
Management alternative	**No.:** 4 **BAUM/AM:** AM **System**: Uneven-aged; cable crane slit-cut **Regeneration:** natural/ artificial **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 150-250 years depending on management intensity **Addressed climate change effect**: intensified bark beetle disturbances **Adaptation strategy (B, RI, AC)**: RI, AC **Expected level for addressed objectives (low, average, high)**: timber production (high), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce
	Artificial regeneration	Of European larch; planted in patches (ca. 17.5 m diameter); 25 plants per patch (2 x 2 m spacing); 25 % of the slit cut are covered by larch patches
	Game management	Ungulate game species (i.e. chamois, roe deer, and red deer) densities are reduced significantly to enhance regeneration of spruce, larch and other species where seeds are available (e.g. rowan, sycamore maple)
Young	Tending	None
Medium	Thinning	None
Adult	Slit cut (regeneration cut)	Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: Disturbances by *Ips typographus* are expected to increase under climate change. Therefore, the artificial regeneration of larch and the game management will decrease the large share of Norway spruce in the regeneration in favour of larch and other species (RI). A broader species set will increase the AC.		

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged pure Norway spruce stands - Soil type: (Semi)podzol; Nutrients (poor, average, high): high; Water(low, average, high): high	
Management alternative	**No.:** 5 **BAUM/AM:** AM **System**: Uneven-aged; modified cable crane slit-cuts **Regeneration:** natural **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 30-60 years **Addressed climate change effect**: intensified bark beetle disturbances, NPP change **Adaptation strategy (B, RI, AC)**: RI, AC, B **Expected level for addressed objectives (low, average, high)**: timber production (high), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce
	Game management	Ungulate game species (i.e. chamois, roe deer, and red deer) densities are reduced significantly to enhance regeneration of spruce and other species where seeds are available (e.g. rowan, sycamore maple)
Young	Tending	None
Medium	Thinning	None
Adult	Slit cuts (regeneration cuts)	The shape of the slit cut is modified. The skyline track is cut diagonal to the slope. From this track slit cuts are cut parallel to the contour lines. These slits have a size of ca. 30-40 m in length and a width of ca. 15-20 m. They are placed every 40-60 m alternating on the left and right hand side of the skyline track. Within the slit cuts everything > 25 cm DBH is cut by motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: Disturbances by *Ips typographus* are expected to increase under climate change. More frequent and larger management actions will reduce the share of over-mature stands (RI) and make better use of possibly increasing growth rates (B). Additionally an adapted game management will decrease the long regeneration time-spans as well as enhance the regeneration of all tree species. A broader species set will increase the AC.		

Stand x site type 7: Uneven-aged pure Norway spruce stands, site 7 (soil type: (Semi)podzol, nutrients: average, water: average)

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged pure Norway spruce stands - Soil type: (Semi)podzol; Nutrients (poor, average, high): average; Water(low, average, high): average	
Management alternative	**No.:** 1 **BAUM/AM:** BAUM1 **System**: **Regeneration:** natural **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** none **Addressed climate change effect**: N/A **Adaptation strategy (B, RI, AC)**: N/A **Expected level for addressed objectives (low, average, high)**: protection against erosion, avalanches, and rock fall (low), biodiversity (low)	
Phase of development	**Process**	**Description**
Regeneration	None	
Young	None	
Medium	None	
Adult	None	
Short description: BAUM schedule for anuneven-aged pure Norway spruce forest in very steep terrain. Due to the terrain no management actions are carried out. Average productivity, average nutrient supply and average water holding capacity and availability. The objectives are protection against erosion, avalanches, landslides and rock fall as well as biodiversity.		

<table>
<tr><td>Case study</td><td colspan="2">3b1 Temperate central alpine - Montafon</td></tr>
<tr><td>Stand x site type</td><td colspan="2">- Uneven-aged pure Norway spruce stands
- Soil type: (Semi)podzol; Nutrients (poor, average, high): average; Water(low, average, high): average</td></tr>
<tr><td>Management alternative</td><td colspan="2">No.: 2
BAUM/AM: BAUM2
System: Uneven-aged; cable crane slit-cut
Regeneration: natural
Thinning type (below, above): none
Thinning intensity (weak, average, heavy): none
Entry interval: 150-250 years depending on management intensity
Addressed climate change effect: N/A
Adaptation strategy (B, RI, AC): N/A
Expected level for addressed objectives (low, average, high): timber production (average), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)</td></tr>
<tr><td>Phase of development</td><td>Process</td><td>Description</td></tr>
<tr><td>Regeneration</td><td>Natural regeneration</td><td>Of spruce; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce</td></tr>
<tr><td>Young</td><td>Tending</td><td>None</td></tr>
<tr><td>Medium</td><td>Thinning</td><td>None</td></tr>
<tr><td>Adult</td><td>Slit cut (regeneration cut)</td><td>Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.</td></tr>
<tr><td colspan="3">Short description: BAUM schedule for anuneven-aged pure Norway spruce in steep terrain (harvesting bound to skyline systems). Average productivity, average nutrient supply and average water holding capacity and availability. The main objective is protection against erosion, avalanches and landslides. Timber production, protection against rock fall, biodiversity, provision of drinking water and are also considered.</td></tr>
</table>

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged pure Norway spruce stands - Soil type: (Semi)podzol; Nutrients (poor, average, high): average; Water(low, average, high): average	
Management alternative	**No.:** 3 **BAUM/AM:** AM **System**: Uneven-aged; cable crane slit-cut **Regeneration:** natural/ artificial **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 150-250 years depending on management intensity **Addressed climate change effect**: intensified bark beetle disturbances **Adaptation strategy (B, RI, AC)**: RI, AC **Expected level for addressed objectives (low, average, high)**: timber production (average), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce
	Artificial regeneration	Of European larch; planted in patches (ca. 17.5 m diameter); 25 plants per patch (2 x 2 m spacing); 25 % of the slit cut are covered by larch patches
Young	Tending	None
Medium	Thinning 1	None
Adult	Slit cut (regeneration cut)	Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: Disturbances by *Ips typographus* are expected to increase under climate change. Therefore the large share of Norway spruce will be decreased by the introduction of European larch (RI). A broader species set will increase the AC.		

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged pure Norway spruce stands - Soil type: (Semi)podzol; Nutrients (poor, average, high): average; Water(low, average, high): average	
Management alternative	**No.:** 4 **BAUM/AM:** AM **System**: Uneven-aged; cable crane slit-cut **Regeneration:** natural/ artificial **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 150-250 years depending on management intensity **Addressed climate change effect**: intensified bark beetle disturbances **Adaptation strategy (B, RI, AC)**: RI, AC **Expected level for addressed objectives (low, average, high)**: timber production (average), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce
	Artificial regeneration	Of European larch; planted in patches (ca. 17.5 m diameter); 25 plants per patch (2 x 2 m spacing); 25 % of the slit cut are covered by larch patches
	Game management	Ungulate game species (i.e. chamois, roe deer, and red deer) densities are reduced significantly to enhance regeneration of spruce, larch and other species where seeds are available (e.g. rowan, sycamore maple)
Young	Tending	None
Medium	Thinning	None
Adult	Slit cut (regeneration cut)	Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: Disturbances by *Ips typographus* are expected to increase under climate change. Therefore, the artificial regeneration of larch and the game management will decrease the large share of Norway spruce in the regeneration in favour of larch and other species (RI). A broader species set will increase the AC.		

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged pure Norway spruce stands - Soil type: (Semi)podzol; Nutrients (poor, average, high): average; Water(low, average, high): average	
Management alternative	**No.:** 5 **BAUM/AM:** AM **System**: Uneven-aged; modified cable crane slit-cuts **Regeneration:** natural **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 30-60 years **Addressed climate change effect**: intensified bark beetle disturbances, NPP change **Adaptation strategy (B, RI, AC)**: RI, AC, B **Expected level for addressed objectives (low, average, high)**: timber production (average), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce
	Game management	Ungulate game species (i.e. chamois, roe deer, and red deer) densities are reduced significantly to enhance regeneration of spruce and other species where seeds are available (e.g. rowan, sycamore maple)
Young	Tending	None
Medium	Thinning	None
Adult	Slit cuts (regeneration cuts)	The shape of the slit cut is modified. The skyline track is cut diagonal to the slope. From this track slit cuts are cut parallel to the contour lines. These slits have a size of ca. 30-40 m in length and a width of ca. 15-20 m. They are placed every 40-60 m alternating on the left and right hand side of the skyline track. Within the slit cuts everything > 25 cm DBH is cut by motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: Disturbances by *Ips typographus* are expected to increase under climate change. More frequent and larger management actions will reduce the share of over-mature stands (RI) and make better use of possibly increasing growth rates (B). Additionally an adapted game management will decrease the long regeneration time-spans as well as enhance the regeneration of all tree species. A broader species set will increase the AC.		

Stand x site type 8: Uneven-aged Norway spruce dominated stands, site 1 (soil type: Rendzina, nutrients: average, water: average)

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged Norway spruce stands with admixed silver fir, European beech and sycamore maple - Soil type: Rendzina; Nutrients (poor, average, high): average; Water(low, average, high): average	
Management alternative	**No.:** 1 **BAUM/AM:** BAUM1 **System**: **Regeneration:** natural **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** none **Addressed climate change effect**: N/A **Adaptation strategy (B, RI, AC)**: N/A **Expected level for addressed objectives (low, average, high)**: protection against erosion, avalanches, and rock fall (low), biodiversity (low)	
Phase of development	**Process**	**Description**
Regeneration	None	
Young	None	
Medium	None	
Adult	None	
Short description: BAUM schedule for anuneven-aged Norway spruce forest with admixed silver fir, European beech and sycamore maple in very steep terrain. Due to the terrain no management actions are carried out. Average productivity, soil with average nutrient supply and average water holding capacity and availability. The objectives are protection against erosion, avalanches, landslides and rock fall as well as biodiversity.		

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged Norway spruce stands with admixed silver fir, European beech and sycamore maple - Soil type: Rendzina; Nutrients (poor, average, high): average; Water(low, average, high): average	
Management alternative	**No.:** 2 **BAUM/AM:** BAUM2 **System**: Uneven-aged; cable crane slit-cut **Regeneration:** natural **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 150-250 years depending on management intensity **Addressed climate change effect**: N/A **Adaptation strategy (B, RI, AC)**: N/A **Expected level for addressed objectives (low, average, high)**: timber production (average), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce, fir, beech and sycamore maple; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce; fir and broadleaved species are heavily browsed thus the share of spruce is >90%
Young	Tending	None
Medium	Thinning	None
Adult	Slit cut (regeneration cut)	Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: BAUM schedule for anuneven-aged Norway spruce forest with admixed silver fir, European beech and sycamore maple in steep terrain (harvesting bound to skyline systems). Average productivity, soil with average nutrient supply and average water holding capacity and availability. The main objective protection against erosion, avalanches and landslides. Timber production, protection against rock fall, biodiversity, provision of drinking water and are also considered.		

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged Norway spruce stands with admixed silver fir, European beech and sycamore maple - Soil type: Rendzina; Nutrients (poor, average, high): average; Water(low, average, high): average	
Management alternative	**No.:** 3 **BAUM/AM:** AM **System**: Uneven-aged; cable crane slit-cut **Regeneration:** natural/ artificial **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 150-250 years depending on management intensity **Addressed climate change effect**: intensified bark beetle disturbances **Adaptation strategy (B, RI, AC)**: RI, AC **Expected level for addressed objectives (low, average, high)**: timber production (average), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce, fir, beech and sycamore maple; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce; fir and broadleaved species are heavily browsed thus the share of spruce is >90%
	Artificial regeneration	Of European larch; planted in patches (ca. 17.5 m diameter); 25 plants per patch (2 x 2 m spacing); 25 % of the slit cut are covered by larch patches
Young	Tending	None
Medium	Thinning 1	None
Adult	Slit cut (regeneration cut)	Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: Disturbances by *Ips typographus* are expected to increase under climate change. Therefore the large share of Norway spruce will be decreased by the introduction of European larch (RI). A broader species set will increase the AC.		

Case study	3b1 Temperate central alpine – Montafon	
Stand x site type	- Uneven-aged Norway spruce stands with admixed silver fir, European beech and sycamore maple - Soil type: Rendzina; Nutrients (poor, average, high): average; Water(low, average, high): average	
Management alternative	**No.:** 4 **BAUM/AM:** AM **System**: Uneven-aged; cable crane slit-cut **Regeneration:** natural **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 150-250 years depending on management intensity **Addressed climate change effect**: intensified bark beetle disturbance **Adaptation strategy (B, RI, AC)**: RI, AC **Expected level for addressed objectives (low, average, high)**: timber production (average), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce, fir, beech and sycamore maple; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration
	Artificial regeneration	Of European larch; planted in patches (ca. 17.5 m diameter); 25 plants per patch (2 x 2 m spacing); 25 % of the slit cut are covered by larch patches
	Game management	Ungulate game species (i.e. chamois, roe deer, and red deer) densities are reduced significantly to enhance regeneration of silver fir and broadleaved species
Young	Tending	None
Medium	Thinning	None
Adult	Slit cut (regeneration cut)	Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: Disturbances by *Ips typographus* are expected to increase under climate change. Therefore, the artificial regeneration of larch and the game management will decrease the large share of Norway spruce in the regeneration in favour of fir, beech, sycamore maple, larch and other species (RI). A broader species set will increase the AC.		

<table>
<tr><td>Case study</td><td colspan="2">3b1 Temperate central alpine - Montafon</td></tr>
<tr><td>Stand x site type</td><td colspan="2">- Uneven-aged Norway spruce stands with admixed silver fir, European beech and sycamore maple
- Soil type: Rendzina; Nutrients (poor, average, high): average; Water(low, average, high): average</td></tr>
<tr><td>Management alternative</td><td colspan="2">No.: 5
BAUM/AM: AM
System: Uneven-aged; modified cable crane slit-cuts
Regeneration: natural
Thinning type (below, above): none
Thinning intensity (weak, average, heavy): none
Entry interval: 30-60 years
Addressed climate change effect: intensified bark beetle disturbances, NPP change
Adaptation strategy (B, RI, AC): RI, AC, B
Expected level for addressed objectives (low, average, high): timber production (average), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)</td></tr>
<tr><td>Phase of development</td><td>Process</td><td>Description</td></tr>
<tr><td>Regeneration</td><td>Natural regeneration</td><td>Of spruce, fir, beech and sycamore maple; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration</td></tr>
<tr><td></td><td>Game management</td><td>Ungulate game species (i.e. chamois, roe deer, and red deer) densities are reduced significantly to enhance regeneration of silver fir and broadleaved species</td></tr>
<tr><td>Young</td><td>Tending</td><td>None</td></tr>
<tr><td>Medium</td><td>Thinning</td><td>None</td></tr>
<tr><td>Adult</td><td>Slit cuts
(regeneration cuts)</td><td>The shape of the slit cut is modified. The skyline track is cut diagonal to the slope. From this track slit cuts are cut parallel to the contour lines. These slits have a size of ca. 30-40 m in length and a width of ca. 15-20 m. They are placed every 40-60 m alternating on the left and right hand side of the skyline track.
Within the slit cuts everything > 25 cm DBH is cut by motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.</td></tr>
<tr><td colspan="3">Short description: Disturbances by Ips typographus are expected to increase under climate change. More frequent and larger management actions will reduce the share of over-mature stands (RI) and make better use of possibly increasing growth rates (B). Additionally an adapted game management will decrease the long regeneration time-spans as well as enhance the regeneration of all tree species. A broader species set will increase the AC.</td></tr>
</table>

Stand x site type 9: Uneven-aged Norway spruce dominated stands, site 2 (soil type: Ranker, nutrients: average, water: high)

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged Norway spruce stands with admixed silver fir, European beech and sycamore maple - Soil type: Ranker; Nutrients (poor, average, high): average; Water(low, average, high): high	
Management alternative	**No.:** 1 **BAUM/AM:** BAUM1 **System**: **Regeneration:** natural **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** none **Addressed climate change effect**: N/A **Adaptation strategy (B, RI, AC)**: N/A **Expected level for addressed objectives (low, average, high)**: protection against erosion, avalanches, and rock fall (low), biodiversity (low)	
Phase of development	**Process**	**Description**
Regeneration	None	
Young	None	
Medium	None	
Adult	None	
Short description: BAUM schedule for anuneven-aged Norway spruce forest with admixed silver fir, European beech and sycamore maple in very steep terrain. Due to the terrain no management actions are carried out. Average productivity, soil with average nutrient supply and high water holding capacity and availability. The objectives are protection against erosion, avalanches, landslides and rock fall as well as biodiversity.		

<table>
<tr><td>Case study</td><td colspan="2">3b1 Temperate central alpine - Montafon</td></tr>
<tr><td>Stand x site type</td><td colspan="2">- Uneven-aged Norway spruce stands with admixed silver fir, European beech and sycamore maple
- Soil type: Ranker; Nutrients (poor, average, high): average; Water(low, average, high): high</td></tr>
<tr><td>Management alternative</td><td colspan="2">No.: 2
BAUM/AM: BAUM2
System: Uneven-aged; cable crane slit-cut
Regeneration: natural
Thinning type (below, above): none
Thinning intensity (weak, average, heavy): none
Entry interval: 150-250 years depending on management intensity
Addressed climate change effect: N/A
Adaptation strategy (B, RI, AC): N/A
Expected level for addressed objectives (low, average, high): timber production (average), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)</td></tr>
<tr><td>Phase of development</td><td>Process</td><td>Description</td></tr>
<tr><td>Regeneration</td><td>Natural regeneration</td><td>Of spruce, fir, beech and sycamore maple; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce; fir and broadleaved species are heavily browsed thus the share of spruce is >90%</td></tr>
<tr><td>Young</td><td>Tending</td><td>None</td></tr>
<tr><td>Medium</td><td>Thinning</td><td>None</td></tr>
<tr><td>Adult</td><td>Slit cut (regeneration cut)</td><td>Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.</td></tr>
<tr><td colspan="3">Short description: BAUM schedule for anuneven-aged Norway spruce forest with admixed silver fir, European beech and sycamore maple in steep terrain (harvesting bound to skyline systems). Average productivity, soil with average nutrient supply and high water holding capacity and availability. The main objective protection against erosion, avalanches and landslides. Timber production, protection against rock fall, biodiversity, provision of drinking water and are also considered.</td></tr>
</table>

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged Norway spruce stands with admixed silver fir, European beech and sycamore maple - Soil type: Ranker; Nutrients (poor, average, high): average; Water(low, average, high): high	
Management alternative	**No.:** 3 **BAUM/AM:** AM **System**: Uneven-aged; cable crane slit-cut **Regeneration:** natural/ artificial **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 150-250 years depending on management intensity **Addressed climate change effect**: intensified bark beetle disturbances **Adaptation strategy (B, RI, AC)**: RI, AC **Expected level for addressed objectives (low, average, high)**: timber production (average), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce, fir, beech and sycamore maple; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce; fir and broadleaved species are heavily browsed thus the share of spruce is >90%
	Artificial regeneration	Of European larch; planted in patches (ca. 17.5 m diameter); 25 plants per patch (2 x 2 m spacing); 25 % of the slit cut are covered by larch patches
Young	Tending	None
Medium	Thinning 1	None
Adult	Slit cut (regeneration cut)	Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: Disturbances by *Ips typographus* are expected to increase under climate change. Therefore the large share of Norway spruce will be decreased by the introduction of European larch (RI). A broader species set will increase the AC.		

Case study	3b1 Temperate central alpine – Montafon	
Stand x site type	- Uneven-aged Norway spruce stands with admixed silver fir, European beech and sycamore maple - Soil type: Ranker; Nutrients (poor, average, high): average; Water(low, average, high): high	
Management alternative	**No.:** 4 **BAUM/AM:** AM **System**: Uneven-aged; cable crane slit-cut **Regeneration:** natural **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 150-250 years depending on management intensity **Addressed climate change effect**: intensified bark beetle disturbance **Adaptation strategy (B, RI, AC)**: RI, AC **Expected level for addressed objectives (low, average, high)**: timber production (average), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce, fir, beech and sycamore maple; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration
	Artificial regeneration	Of European larch; planted in patches (ca. 17.5 m diameter); 25 plants per patch (2 x 2 m spacing); 25 % of the slit cut are covered by larch patches
	Game management	Ungulate game species (i.e. chamois, roe deer, and red deer) densities are reduced significantly to enhance regeneration of silver fir and broadleaved species
Young	Tending	None
Medium	Thinning	None
Adult	Slit cut (regeneration cut)	Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: Disturbances by *Ips typographus* are expected to increase under climate change. Therefore, the artificial regeneration of larch and the game management will decrease the large share of Norway spruce in the regeneration in favour of fir, beech, sycamore maple, larch and other species (RI). A broader species set will increase the AC.		

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged Norway spruce stands with admixed silver fir, European beech and sycamore maple - Soil type: Ranker; Nutrients (poor, average, high): average; Water(low, average, high): high	
Management alternative	**No.:** 5 **BAUM/AM:** AM **System**: Uneven-aged; modified cable crane slit-cuts **Regeneration:** natural **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 30-60 years **Addressed climate change effect**: intensified bark beetle disturbances, NPP change **Adaptation strategy (B, RI, AC)**: RI, AC, B **Expected level for addressed objectives (low, average, high)**: timber production (average), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce, fir, beech and sycamore maple; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration
	Game management	Ungulate game species (i.e. chamois, roe deer, and red deer) densities are reduced significantly to enhance regeneration of silver fir and broadleaved species
Young	Tending	None
Medium	Thinning	None
Adult	Slit cuts (regeneration cuts)	The shape of the slit cut is modified. The skyline track is cut diagonal to the slope. From this track slit cuts are cut parallel to the contour lines. These slits have a size of ca. 30-40 m in length and a width of ca. 15-20 m. They are placed every 40-60 m alternating on the left and right hand side of the skyline track. Within the slit cuts everything > 25 cm DBH is cut by motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: Disturbances by *Ips typographus* are expected to increase under climate change. More frequent and larger management actions will reduce the share of over-mature stands (RI) and make better use of possibly increasing growth rates (B). Additionally an adapted game management will decrease the long regeneration time-spans as well as enhance the regeneration of all tree species. A broader species set will increase the AC.		

Stand x site type 10: Uneven-aged Norway spruce dominated stands, site 4 (soil type: Cambisol, nutrients: high, water: high)

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged Norway spruce stands with admixed silver fir, European beech and sycamore maple - Soil type: Cambisol; Nutrients (poor, average, high): high; Water(low, average, high): high	
Management alternative	**No.:** 2 **BAUM/AM:** BAUM2 **System**: Uneven-aged; cable crane slit-cut **Regeneration:** natural **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 150-250 years depending on management intensity **Addressed climate change effect**: N/A **Adaptation strategy (B, RI, AC)**: N/A **Expected level for addressed objectives (low, average, high)**: timber production (high), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce, fir, beech and sycamore maple; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce; fir and broadleaved species are heavily browsed thus the share of spruce is >90%
Young	Tending	None
Medium	Thinning	None
Adult	Slit cut (regeneration cut)	Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: BAUM schedule for anuneven-aged Norway spruce forest with admixed silver fir, European beech and sycamore maple in steep terrain (harvesting bound to skyline systems). High productivity,soil withhigh nutrient supply and high water holding capacity and availability. The main objective is timber production and protection against erosion, avalanches and landslides. Protection against rock fall, biodiversity, provision of drinking water and are also considered.		

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged Norway spruce stands with admixed silver fir, European beech and sycamore maple - Soil type: Cambisol; Nutrients (poor, average, high): high; Water(low, average, high): high	
Management alternative	**No.:** 3 **BAUM/AM:** AM **System**: Uneven-aged; cable crane slit-cut **Regeneration:** natural/ artificial **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 150-250 years depending on management intensity **Addressed climate change effect**: intensified bark beetle disturbances **Adaptation strategy (B, RI, AC)**: RI, AC **Expected level for addressed objectives (low, average, high)**: timber production (high), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce, fir, beech and sycamore maple; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce; fir and broadleaved species are heavily browsed thus the share of spruce is >90%
	Artificial regeneration	Of European larch; planted in patches (ca. 17.5 m diameter); 25 plants per patch (2 x 2 m spacing); 25 % of the slit cut are covered by larch patches
Young	Tending	None
Medium	Thinning 1	None
Adult	Slit cut (regeneration cut)	Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: Disturbances by *Ips typographus* are expected to increase under climate change. Therefore the large share of Norway spruce will be decreased by the introduction of European larch (RI). A broader species set will increase the AC.		

Case study	3b1 Temperate central alpine – Montafon	
Stand x site type	- Uneven-aged Norway spruce stands with admixed silver fir, European beech and sycamore maple - Soil type: Cambisol; Nutrients (poor, average, high): high; Water(low, average, high): high	
Management alternative	**No.:** 4 **BAUM/AM:** AM **System**: Uneven-aged; cable crane slit-cut **Regeneration:** natural **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 150-250 years depending on management intensity **Addressed climate change effect**: intensified bark beetle disturbance **Adaptation strategy (B, RI, AC)**: RI, AC **Expected level for addressed objectives (low, average, high)**: timber production (high), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce, fir, beech and sycamore maple; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration
	Artificial regeneration	Of European larch; planted in patches (ca. 17.5 m diameter); 25 plants per patch (2 x 2 m spacing); 25 % of the slit cut are covered by larch patches
	Game management	Ungulate game species (i.e. chamois, roe deer, and red deer) densities are reduced significantly to enhance regeneration of silver fir and broadleaved species
Young	Tending	None
Medium	Thinning	None
Adult	Slit cut (regeneration cut)	Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: Disturbances by *Ips typographus* are expected to increase under climate change. Therefore, the artificial regeneration of larch and the game management will decrease the large share of Norway spruce in the regeneration in favour of fir, beech, sycamore maple, larch and other species (RI). A broader species set will increase the AC.		

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged Norway spruce stands with admixed silver fir, European beech and sycamore maple - Soil type: Cambisol; Nutrients (poor, average, high): high; Water(low, average, high): high	
Management alternative	**No.:** 5 **BAUM/AM:** AM **System**: Uneven-aged; modified cable crane slit-cuts **Regeneration:** natural **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 30-60 years **Addressed climate change effect**: intensified bark beetle disturbances, NPP change **Adaptation strategy (B, RI, AC)**: RI, AC, B **Expected level for addressed objectives (low, average, high)**: timber production (high), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce, fir, beech and sycamore maple; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration
	Game management	Ungulate game species (i.e. chamois, roe deer, and red deer) densities are reduced significantly to enhance regeneration of silver fir and broadleaved species
Young	Tending	None
Medium	Thinning	None
Adult	Slit cuts (regeneration cuts)	The shape of the slit cut is modified. The skyline track is cut diagonal to the slope. From this track slit cuts are cut parallel to the contour lines. These slits have a size of ca. 30-40 m in length and a width of ca. 15-20 m. They are placed every 40-60 m alternating on the left and right hand side of the skyline track. Within the slit cuts everything > 25 cm DBH is cut by motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: Disturbances by *Ips typographus* are expected to increase under climate change. More frequent and larger management actions will reduce the share of over-mature stands (RI) and make better use of possibly increasing growth rates (B). Additionally an adapted game management will decrease the long regeneration time-spans as well as enhance the regeneration of all tree species. A broader species set will increase the AC.		

Stand x site type 11: Uneven-aged Norway spruce dominated stands, site 5 (soil type: poor Cambisol, nutrients: average, water: high)

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged Norway spruce stands with admixed silver fir, European beech and sycamore maple - Soil type: poor Cambisol; Nutrients (poor, average, high): average; Water(low, average, high): high	
Management alternative	**No.:** 2 **BAUM/AM:** BAUM2 **System**: Uneven-aged; cable crane slit-cut **Regeneration:** natural **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 150-250 years depending on management intensity **Addressed climate change effect**: N/A **Adaptation strategy (B, RI, AC)**: N/A **Expected level for addressed objectives (low, average, high)**: timber production (average), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce, fir, beech and sycamore maple; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce; fir and broadleaved species are heavily browsed thus the share of spruce is >90%
Young	Tending	None
Medium	Thinning	None
Adult	Slit cut (regeneration cut)	Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: BAUM schedule for anuneven-aged Norway spruce forest with admixed silver fir, European beech and sycamore maple in steep terrain (harvesting bound to skyline systems). Average productivity, soil with average nutrient supply and high water holding capacity and availability. The main objective protection against erosion, avalanches and landslides. Timber production, protection against rock fall, biodiversity, provision of drinking water and are also considered.		

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged Norway spruce stands with admixed silver fir, European beech and sycamore maple - Soil type: poor Cambisol; Nutrients (poor, average, high): average; Water(low, average, high): high	
Management alternative	**No.:** 3 **BAUM/AM:** AM **System**: Uneven-aged; cable crane slit-cut **Regeneration:** natural/ artificial **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 150-250 years depending on management intensity **Addressed climate change effect**: intensified bark beetle disturbances **Adaptation strategy (B, RI, AC)**: RI, AC **Expected level for addressed objectives (low, average, high)**: timber production (average), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce, fir, beech and sycamore maple; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration of spruce; fir and broadleaved species are heavily browsed thus the share of spruce is >90%
	Artificial regeneration	Of European larch; planted in patches (ca. 17.5 m diameter); 25 plants per patch (2 x 2 m spacing); 25 % of the slit cut are covered by larch patches
Young	Tending	None
Medium	Thinning 1	None
Adult	Slit cut (regeneration cut)	Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: Disturbances by *Ips typographus* are expected to increase under climate change. Therefore the large share of Norway spruce will be decreased by the introduction of European larch (RI). A broader species set will increase the AC.		

Case study	3b1 Temperate central alpine – Montafon	
Stand x site type	- Uneven-aged Norway spruce stands with admixed silver fir, European beech and sycamore maple - Soil type: poor Cambisol; Nutrients (poor, average, high): average; Water(low, average, high): high	
Management alternative	**No.:** 4 **BAUM/AM:** AM **System**: Uneven-aged; cable crane slit-cut **Regeneration:** natural **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 150-250 years depending on management intensity **Addressed climate change effect**: intensified bark beetle disturbance **Adaptation strategy (B, RI, AC)**: RI, AC **Expected level for addressed objectives (low, average, high)**: timber production (average), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce, fir, beech and sycamore maple; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration
	Artificial regeneration	Of European larch; planted in patches (ca. 17.5 m diameter); 25 plants per patch (2 x 2 m spacing); 25 % of the slit cut are covered by larch patches
	Game management	Ungulate game species (i.e. chamois, roe deer, and red deer) densities are reduced significantly to enhance regeneration of silver fir and broadleaved species
Young	Tending	None
Medium	Thinning	None
Adult	Slit cut (regeneration cut)	Skyline track is used as regeneration cut diagonal to the slope; the skyline track is irregularly shaped, with a width of 5 to 40 m, ~25 m on average. Within the track everything > 25 cm DBH is cut. Motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: Disturbances by *Ips typographus* are expected to increase under climate change. Therefore, the artificial regeneration of larch and the game management will decrease the large share of Norway spruce in the regeneration in favour of fir, beech, sycamore maple, larch and other species (RI). A broader species set will increase the AC.		

Case study	3b1 Temperate central alpine - Montafon	
Stand x site type	- Uneven-aged Norway spruce stands with admixed silver fir, European beech and sycamore maple - Soil type: poor Cambisol; Nutrients (poor, average, high): average; Water(low, average, high): high	
Management alternative	**No.:** 5 **BAUM/AM:** AM **System**: Uneven-aged; modified cable crane slit-cuts **Regeneration:** natural **Thinning type (below, above):** none **Thinning intensity (weak, average, heavy):** none **Entry interval:** 30-60 years **Addressed climate change effect**: intensified bark beetle disturbances, NPP change **Adaptation strategy (B, RI, AC)**: RI, AC, B **Expected level for addressed objectives (low, average, high)**: timber production (average), protection against erosion, avalanches and landslides (high), protection against rock fall (average), biodiversity (low), provision of drinking water (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Of spruce, fir, beech and sycamore maple; long regeneration time-spans, regeneration often limited by ground vegetation, lying dead wood and stumps act as favorable microsites for regeneration
	Game management	Ungulate game species (i.e. chamois, roe deer, and red deer) densities are reduced significantly to enhance regeneration of silver fir and broadleaved species
Young	Tending	None
Medium	Thinning	None
Adult	Slit cuts (regeneration cuts)	The shape of the slit cut is modified. The skyline track is cut diagonal to the slope. From this track slit cuts are cut parallel to the contour lines. These slits have a size of ca. 30-40 m in length and a width of ca. 15-20 m. They are placed every 40-60 m alternating on the left and right hand side of the skyline track. Within the slit cuts everything > 25 cm DBH is cut by motor manual harvesting. Existing regeneration patches are promoted by intensified harvesting activities (i.e. widening of the slit) to provide light. Cut to length yarding with cable crane system.
Short description: Disturbances by *Ips typographus* are expected to increase under climate change. More frequent and larger management actions will reduce the share of over-mature stands (RI) and make better use of possibly increasing growth rates (B). Additionally an adapted game management will decrease the long regeneration time-spans as well as enhance the regeneration of all tree species. A broader species set will increase the AC.		

Continental Bulgaria case (5a)

- We changed a little bit the template the first phase of development in our case is regeneration cut, because most of our coppice forests are about at age 50 and in management plans usually is written that they should be transformed into high. After that, we should treat (manage) them as high forests.

Stand x site type xx: Even-aged …stands, site xx (soil type: xx, nutrients: xx, water: xx)

Case study	Bulgaria	
Stand x site type	- Even-aged coppice Sessile oak - Soil type: xxx ; Nutrients[9] (poor, average, high): xxx ; Water[1] (low, average, high): xxx, nutrients – average, water – average	
Management alternative	**No.: 1** **BAUM/AM: BAUM** **System**: Even-aged shelter, irregular shelter **Regeneration:** natural – seed and sprout **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:** .5-10 **Addressed climate change effect**: **Adaptation strategy (B, RI, AC)**: **Expected level for addressed objectives (low, average, high)**: timber production (high), carbon sequestration (average), biodiversity (high)	
Phase of development	**Process**	**Description**
Adult coppice	Regeneration cut – (transformation cut) coppice to be transformed into high, shelter, irregular shelter	A = 80 - Maximum rotation age N = 380 stems/ha D_{mean} = 28 cm G = 23.4 m2/ha
Regeneration	➢ species composition ➢ seed ➢ sprout	Sessile oak. 8(9), (Q. cerris, Q. frainetto, Fraxinus ornus, Carpinus betulus, Carpinus orientalis) 80% seed; 20% sprout
Young	Tending	A (age) = 0-15 H = 6.4 m 90% seed. 10% sprout
	Tending 2	A = 20-40 N_{seed} = 2900 stem/ha, D_{mean} 10 cm N_{sprout}= 300 stem/ha D_{mean} 12 cm G = 19.8 m^2/ha Thinning intensity = 20-25%
Medium	Thinning 1	A = 40-60 N_{seed} = 900 stem/ha, D_{mean} 18 cm N_{sprout}= 100 stem/ha D_{mean} 18.7 cm G =21.8m^2/ha Thinning intensity = 20-25%
	Thinning 2	A = 60-90 Nseed = 300 stem/ha. D_{mean} 30cm Nsprout = 50 stem/ha. D_{mean} 28 cm G =22m^2/ha Thinning intensity = 20-25%
Adult mostly high oak forest	Regeneration cut shelterwood and irregular shelterwood system) 2-3 phases	A = 120 N = 150 stem/ha D_{mean} = 43 cm G = 21 m^2/ha

[9]“Nutrients” refers to (content x availability); “Water” refers to (holding capacity x availability)

Case study	Bulgaria	
Stand x site type	- Even-aged coppice Sessile oak - Soil type: xxx ; Nutrients (poor, average, high): xxx ; Water(low, average, high): xxx, nutrients – poor, water – low to average	
Management alternative	**No.: 2** **BAUM/AM: BAUM** **System**: Even-aged shelter, irregular shelter **Regeneration:** natural – seed and sprout **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:** .5-10 **Addressed climate change effect**: **Adaptation strategy (B, RI, AC)**: **Expected level for addressed objectives (low, average, high)**: timber production (high), carbon sequestration (average), biodiversity (high)	
Phase of development	**Process**	**Description**
Adult coppice	Regeneration cut – (transformation cut) coppice to be transformed into high, shelter, irregular shelter	A = 50 - Maximum rotation age N = 850 stems/ha D_{mean} = 16 cm G = 17.1 m^2/ha
Regeneration	➢ species composition ➢ seed ➢ sprout	Sessille oak. 7(8), (Q. cerris, Q. frainetto, Fraxinus ornus, Carpinus betulus, Carpinus orientalis) 50% seed 50% sprout
Young	Tending	A (age) = 0-10 H = 3.4 m 75% seed. 25% sprout
	Tending 2	A = 15-30 N_{seed} = 4630 stem/ha, D_{mean} 6 cm N_{sprout}= 770 stem/ha D_{mean}8 cm G = 14.4 m^2/ha Thinning intensity = 20-25%
Medium	Thinning 1	A = 30-60 N_{seed} = 2100 stem/ha, D_{mean} 13 cm N_{sprout} = 370 stem/ha D_{mean}14 cm G =21.1m^2/ha Thinning intensity = 20-25%
	Thinning 2	A = 60-90 N_{seed} = 720stem/ha. D_{mean}20cm N_{sprout} = 170 stem/ha. D_{mean} 20 cm G =19.6m^2/ha Thinning intensity = 20-25%
Adult mostly high oak forest	Regeneration cut shelterwood and irregular shelterwood system) 2-3 phases	A = 120 N = 240 stem/ha D_{mean} = 32 cm G = 19.3 m^2/ha

Case study	Bulgaria	
Stand x site type	- Even-aged coppice Sessile oak - Soil type: xxx ; Nutrients (poor, average, high): xxx ; Water(low, average, high): xxx, nutrients – average, water – low to average	
Management alternative	**No.: 3** **BAUM/AM: AM** **System**: Even-aged shelter, irregular shelter **Regeneration:** natural – seed and sprout **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:** .5-10 **Addressed climate change effect**:drought, more frequent forest fires **Adaptation strategy (B, RI, AC)**: AC, RI **Expected level for addressed objectives (low, average, high)**: timber production (average), carbon sequestration (average), biodiversity (average)	
Phase of development	**Process**	**Description**
Adult coppice	Regeneration cut – (transformation cut) coppice to be transformed into high, shelter, irregular shelter	A = 60 - Maximum rotation age N = 540 stems/ha D_{mean} = 20 cm G = 16,9 m^2/ha
Regeneration	➢ species composition ➢ seed ➢ sprout ➢ afforestation	Sessille oak. 3(4), (Q. cerris, Q. frainettop Q. pubescens, Fraxinus ornus, Carpinus betulus, Carpinus orientalis) 60-70% seed 40-30% sprout 5-10 % (Q. cerris, Q. frainettop Q. pubescens, cedars)
Young	Tending	A (age) = 0-10 H = 4.2 m 50% seed. 50% sprout
	Tending 2	A = 15-25 N_{seed} = 4400 stem/ha, D_{mean} 4.5 cm N_{sprout}= 990 stem/ha D_{mean} 7 cm G = 19.8 m^2/ha Thinning intensity = 20-25%
Medium	Thinning 1	A = 30-50 N_{seed} = 1850 stem/ha, D_{mean} 12 cm N_{sprout} = 480 stem/ha D_{mean}14 cm G =21.8m^2/ha Thinning intensity = 20%
	Thinning 2	A = 50-80 N_{seed} = 510stem/ha. D_{mean}22cm N_{sprout} = 150 stem/ha. D_{mean} 24 cm G =18.4m^2/ha Thinning intensity = 20%
Adult mostly high oak forest	Regeneration cut shelterwood and irregular shelterwood system) 2-3 phases	A = 100 N = 170 stem/ha D_{mean} = 32 cm G = 13.7 m^2/ha

Case study	Bulgaria	
Stand x site type	- Even-aged coppice Sessile oak - Soil type: xxx ; Nutrients (poor, average, high): xxx ; Water(low, average, high): xxx, nutrients – poor, water – low	
Management alternative	**No.: 4** **BAUM/AM: AM** **System**: Even-aged shelter, irregular shelter **Regeneration:** natural – seed and sprout **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** weak **Entry interval:** .5-10 **Addressed climate change effect**:drought, more frequent forest fires **Adaptation strategy (B, RI, AC)**: AC, RI **Expected level for addressed objectives (low, average, high)**: timber production (average), carbon sequestration (average), biodiversity (average)	
Phase of development	**Process**	**Description**
Adult coppice	Regeneration cut – (transformation cut) coppice to be transformed into high, shelter, irregular shelter	A = 40 - Maximum rotation age N = 1020 stems/ha D_{mean} = 14 cm G = 15.7 m^2/ha
Regeneration	➢ species composition ➢ seed ➢ sprout ➢ afforestation	Sessille oak. 1(2), (Q. cerris, Q. frainettop Q. pubescens, Fraxinus ornus, Carpinus betulus, Carpinus orientalis) 40-50% seed 60-50% sprout 5-10 % (Q. cerris,Q. pubescens, cedars)
Young	Tending	A (age) = 0-10 H = 3.2 m 40% seed. 60% sprout
	Tending 2	A = 10-20 N_{seed} = 2780 stem/ha, D_{mean} 3 cm N_{sprout}= 4550 stem/ha D_{mean} 3 cm G = 5.2 m^2/ha Thinning intensity = 10%
Medium	Thinning 1	A = 20-40 N_{seed} = 1430 stem/ha, D_{mean} 6 cm N_{sprout} = 1530 stem/ha D_{mean}10 cm G =16.1m^2/ha Thinning intensity = 15%
	Thinning 2	A = 40-60 N_{seed} = 480stem/ha. D_{mean}10cm N_{sprout} = 650 stem/ha. D_{mean} 17 cm G =13m^2/ha Thinning intensity = 15%
Adult mostly high oak forest	Regeneration cut shelterwood and irregular shelterwood system) 2-3 phases	A = 80 N = 340 stem/ha D_{mean} = 20 cm G = 10.6 m^2/ha

Case study	Bulgaria	
Stand x site type	- Even-aged coppice Hungarian oak - Soil type: xxx ; Nutrients (poor, average, high): xxx ; Water(low, average, high): xxx, nutrients – average, water – average	
Management alternative	**No.: 5** **BAUM/AM: BAUM** **System**: Even-aged shelter, irregular shelter **Regeneration:** natural – seed and sprout **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:** .5-10 **Addressed climate change effect**: **Adaptation strategy (B, RI, AC)**: **Expected level for addressed objectives (low, average, high)**: timber production (high), carbon sequestration (average), biodiversity (high)	
Phase of development	**Process**	**Description**
Adult coppice	Regeneration cut – (transformation cut) coppice to be transformed into high, shelter, irregular shelter	A = 90 - Maximum rotation age N = 590 stems/ha D_{mean} = 28 cm G = 25.4 m^2/ha
Regeneration	➢ species composition ➢ seed ➢ sprout	Hungarian oak. 6(7), (Q. cerris, Q. sessiliflora, Fraxinus ornus, Carpinus betulus, Carpinus orientalis) 70% seed 30% sprout
Young	Tending	A (age) = 0-15 H = 5.6 m 90% seed. 10% sprout
	Tending 2	A = 20-40 N_{seed} = 3380 stem/ha, D_{mean} 8 cm N_{sprout}= 300stem/ha D_{mean}11 cm G = 16.8 m^2/ha Thinning intensity = 20-25%
Medium	Thinning 1	A = 40-60 N_{seed} = 1550 stem/ha, D_{mean} 14 cm N_{sprout} = 180 stem/ha D_{mean}16 cm G =20.6m^2/ha Thinning intensity = 20-25%
	Thinning 2	A = 60-80 N_{seed} = 900stem/ha. D_{mean}21cm N_{sprout} = 90 stem/ha. D_{mean} 24 cm G =24.7m^2/ha Thinning intensity = 20-25%
Adult mostly high oak forest	Regeneration cut shelterwood and irregular shelterwood system) 2-3 phases	A = 140 N = 300 stem/ha D_{mean} = 38 cm G = 23.8 m^2/ha

Case study	Bulgaria	
Stand x site type	- Even-aged coppice Hungarian oak - Soil type: xxx ; Nutrients (poor, average, high): xxx ; Water(low, average, high): xxx, nutrients – average, water – low to average	
Management alternative	**No.: 6** **BAUM/AM: BAUM** **System**: Even-aged shelter, irregular shelter **Regeneration:** natural – seed and sprout **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:** .5-10 **Addressed climate change effect**: **Adaptation strategy (B, RI, AC)**: **Expected level for addressed objectives (low, average, high)**: timber production (high), carbon sequestration (average), biodiversity (high)	
Phase of development	**Process**	**Description**
Adult coppice	Regeneration cut – (transformation cut) coppice to be transformed into high, shelter, irregular shelter	A = 60 - Maximum rotation age N = 890 stems/ha D_{mean} = 20 cm G = 19.6 m^2/ha
Regeneration	➢ species composition ➢ seed ➢ sprout	Hungarian oak. 5(6), (Q. cerris, Q. sessiliflora, Fraxinus ornus, Carpinus betulus, Carpinus orientalis) 50% seed 50% sprout
Young	Tending	A (age) = 0-10 H = 3.2 m 75% seed. 25% sprout
	Tending 2	A = 10-20 N_{seed} = 3270 stem/ha, D_{mean} 6 cm N_{sprout}= 700stem/ha D_{mean}7 cm G = 10.1 m^2/ha Thinning intensity = 20-25%
Medium	Thinning 1	A = 20-50 N_{seed} = 1690 stem/ha, D_{mean} 10 cm N_{sprout} = 470 stem/ha D_{mean}12 cm G =13.9m^2/ha Thinning intensity = 20-25%
	Thinning 2	A = 50-80 N_{seed} = 970stem/ha. D_{mean}16cm N_{sprout} = 200 stem/ha. D_{mean} 16 cm G =17.6m^2/ha Thinning intensity = 20-25%
Adult mostly high oak forest	Regeneration cut shelterwood and irregular shelterwood system) 2-3 phases	A = 140 N = 300 stem/ha D_{mean} = 26 cm G = 18.2 m^2/ha

Case study	Bulgaria	
Stand x site type	- Even-aged coppice Hungarian oak - Soil type: xxx ; Nutrients (poor, average, high): xxx ; Water(low, average, high): xxx, nutrients – average, water – low to average	
Management alternative	**No.: 7** **BAUM/AM: AM** **System**: Even-aged shelter, irregular shelter **Regeneration:** natural – seed and sprout **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** weak **Entry interval:** .5-10 **Addressed climate change effect**:drought, more frequent forest fires **Adaptation strategy (B, RI, AC)**: AC, RI **Expected level for addressed objectives (low, average, high)**: timber production (average), carbon sequestration (average), biodiversity (average)	
Phase of development	**Process**	**Description**
Adult coppice	Regeneration cut – (transformation cut) coppice to be transformed into high, shelter, irregular shelter	A = 60 - Maximum rotation age N = 870 stems/ha D_{mean} = 20 cm G = 19.1 m^2/ha
Regeneration	➢ species composition ➢ seed ➢ sprout ➢ afforest.	Hungarian oak. 4(5), (Q. cerris, Q. sessiliflora, Fraxinus ornus, Carpinus betulus, Carpinus orientalis) 60-70% seed 40-30% sprout 5-10% ((Q. cerris, Q. frainettop Q. pubescens, cedars)
Young	Tending	A (age) = 0-10 H = 3.2 m 50% seed. 50% sprout
	Tending 2	A = 10-20 N_{seed} = 3130 stem/ha, D_{mean} 4 cm N_{sprout}= 2260 stem/ha D_{mean} 8 cm G = 15.3 m^2/ha Thinning intensity = 10-15%
Medium	Thinning 1	A = 20-50 ; N_{seed} = 2050 stem/ha, D_{mean} 7 cm N_{sprout} = 1440 stem/ha D_{mean}11 cm G =15.3m^2/ha Thinning intensity = 10-15%
	Thinning 2	A = 50-80 N_{seed} = 690stem/ha. D_{mean}17cm N_{sprout} = 480 stem/ha. D_{mean} 20 cm G =21.5m^2/ha Thinning intensity = 20-25%
Adult mostly high oak forest	Regeneration cut shelterwood and irregular shelterwood system) 2-3 phases	A = 90 N = 470 stem/ha D_{mean} = 22 cm G = 17.8 m^2/ha

Case study	Bulgaria	
Stand x site type	- Even-aged coppice Hungarian oak - Soil type: xxx ; Nutrients (poor, average, high): xxx ; Water(low, average, high): xxx, nutrients – average, water – low	
Management alternative	**No.: 8** **BAUM/AM: AM** **System**: Even-aged shelter, irregular shelter **Regeneration:** natural – seed and sprout **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** weak **Entry interval:** .5-10 **Addressed climate change effect**:drought, more frequent forest fires **Adaptation strategy (B, RI, AC)**: AC, RI **Expected level for addressed objectives (low, average, high)**: timber production (average), carbon sequestration (average), biodiversity (average)	
Phase of development	**Process**	**Description**
Adult coppice	Regeneration cut – (transformation cut) coppice to be transformed into high, shelter, irregular shelter	A = 50 - Maximum rotation age N = 1360 stems/ha D_{mean} = 12 cm G = 15.4 m^2/ha
Regeneration	➢ species composition ➢ seed ➢ sprout ➢ afforest.	Hungarian oak. 3(4), (Q. cerris, Q. sessiliflora, Fraxinus ornus, Carpinus betulus, Carpinus orientalis) 40-50% seed 60-50% sprout 10-15% (Q. cerris,Q. pubescens, cedars)
Young	Tending	A (age) = 0-15 H = 2.9 m 40% seed. 60% sprout
	Tending 2	A = 15-25 N_{seed} = 4280 stem/ha, D_{mean} 3 cm N_{sprout}= 4950 stem/ha D_{mean} 5 cm G = 10.8 m^2/ha Thinning intensity = 10%
Medium	Thinning 1	A = 25-40 N_{seed} = 2230 stem/ha, D_{mean} 6 cm N_{sprout} = 2670 stem/ha D_{mean} 8 cm G =14.8m^2/ha Thinning intensity = 15%
	Thinning 2	A = 40-60 N_{seed} = 750stem/ha. D_{mean}10cm N_{sprout} = 800 stem/ha. D_{mean} 12 cm G =10.4m^2/ha Thinning intensity = 15%
Adult mostly high oak forest	Regeneration cut shelterwood and irregular shelterwood system) 2-3 phases	A = 70 N = 520 stem/ha ; D_{mean} = 16 cm ; G = 10.5 m^2/ha

Case study	Bulgaria	
Stand x site type	- Even-aged coppice Turkey oak - Soil type: xxx ; Nutrients (poor, average, high): xxx ; Water(low, average, high): xxx, nutrients – average, water – average	
Management alternative	**No.: 9** **BAUM/AM: BAUM** **System**: Even-aged shelter, irregular shelter **Regeneration:** natural – seed and sprout **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:** .5-10 **Addressed climate change effect**: **Adaptation strategy (B, RI, AC)**: **Expected level for addressed objectives (low, average, high)**: timber production (high), carbon sequestration (average), biodiversity (high)	
Phase of development	**Process**	**Description**
Adult coppice	Regeneration cut – (transformation cut) coppice to be transformed into high, shelter, irregular shelter	A = 60 - Maximum rotation age N = 750 stems/ha D_{mean} = 26cm G = 27.8 m^2/ha
Regeneration	➢ species composition ➢ seed ➢ sprout	Turkey oak. 10, (Q. sessiliflora, Q. frainetto, Fraxinus ornus, Carpinus betulus, Carpinus orientalis) 80% seed 20% sprout
Young	Tending	A (age) = 0-10 H = 6.8 m 90% seed. 10% sprout
	Tending 2	A = 10-20 N_{seed} = 2290 stem/ha, D_{mean} 8 cm N_{sprout}= 350 stem/ha D_{mean}10 cm G = 11.8 m^2/ha Thinning intensity = 20-25%
Medium	Thinning 1	A = 30-60 N_{seed} = 1000 stem/ha, D_{mean} 18 cm N_{sprout} = 150 stem/ha D_{mean}20 cm G =22.6m^2/ha Thinning intensity = 20-25%
	Thinning 2	A = 60-90 N_{seed} = 590stem/ha. D_{mean}26cm N_{sprout} = 60 stem/ha. D_{mean} 30 cm G =24.8m^2/ha Thinning intensity = 20-25%
Adult mostly high oak forest	Regeneration cut shelterwood and irregular shelterwood system); 2-3 phases	A = 100 N = 450 stem/ha D_{mean} = 32 cm ; G = 25.3 m^2/ha

Case study	Bulgaria	
Stand x site type	- Even-aged coppice Turkey oak - Soil type: xxx ; Nutrients (poor, average, high): xxx ; Water(low, average, high): xxx, nutrients – average, water – low to average	
Management alternative	**No.: 10** **BAUM/AM: BAUM** **System**: Even-aged shelter, irregular shelter **Regeneration:** natural – seed and sprout **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:** .5-10 **Addressed climate change effect**: **Adaptation strategy (B, RI, AC)**: **Expected level for addressed objectives (low, average, high)**: timber production (high), carbon sequestration (average), biodiversity (high)	
Phase of development	**Process**	**Description**
Adult coppice	Regeneration cut – (transformation cut) coppice to be transformed into high, shelter, irregular shelter	A = 40 - Maximum rotation age N = 1730 stems/ha D_{mean} = 12cm G = 19.6 m^2/ha
Regeneration	➢ species composition ➢ seed ➢ sprout	Turkey oak. 10, (Q. sessiliflora, Q. frainetto, Fraxinus ornus, Carpinus betulus, Carpinus orientalis) 50% seed 50% sprout
Young	Tending	A (age) = 0-10 H = 4.7 m 75% seed. 25% sprout
	Tending 2	A = 10-20 N_{seed} = 2710 stem/ha, D_{mean} 8 cm N_{sprout}= 530 stem/ha D_{mean}10 cm G = 13.1 m^2/ha Thinning intensity = 20-25%
Medium	Thinning 1	A = 25-40 N_{seed} = 1450 stem/ha, D_{mean} 12 cm N_{sprout} = 280 stem/ha D_{mean}12 cm G =14.8m^2/ha Thinning intensity = 20-25%
	Thinning 2	A = 45-70 N_{seed} = 830stem/ha. D_{mean}19cm N_{sprout} = 130 stem/ha. D_{mean} 17 cm G =18.5m^2/ha Thinning intensity = 20-25%
Adult mostly high oak forest	Regeneration cut shelterwood and irregular shelterwood system) 2-3 phases	A = 80 N = 600 stem/ha D_{mean} = 24cm G = 19 m^2/ha

Case study	Bulgaria	
Stand x site type	- Even-aged coppice Turkey oak - Soil type: xxx ; Nutrients (poor, average, high): xxx ; Water(low, average, high): xxx, nutrients – average, water – low to average	
Management alternative	**No.: 11** **BAUM/AM: AM** **System**: Even-aged shelter, irregular shelter **Regeneration:** natural – seed and sprout **Thinning type (below, above):** above **Thinning intensity (weak, average, heavy):** average **Entry interval:** .5-10 **Addressed climate change effect**:drought, more frequent forest fires **Adaptation strategy (B, RI, AC)**: AC, RI **Expected level for addressed objectives (low, average, high)**: timber production (average), carbon sequestration (average), biodiversity (average)	
Phase of development	**Process**	**Description**
Adult coppice	Regeneration cut – (transformation cut) coppice to be transformed into high, shelter, irregular shelter	A = 60 - Maximum rotation age N = 750 stems/ha D_{mean} = 24cm G = 23.7 m^2/ha
Regeneration	➢ species composition ➢ seed ➢ sprout ➢ afforest.	Turkey oak. 8 (9), (Q.pubescens, Fraxinus ornus, Carpinus betulus, Carpinus orientalis) 70% seed 30% sprout 5-10%(Q.cerris, Q. pubescens, cedar)
Young	Tending	A (age) = 0-10 H = 4.9 m 90% seed. 10% sprout
	Tending 2	A = 10-20 N_{seed} = 1920 stem/ha, D_{mean} 7 cm N_{sprout}= 1050 stem/ha D_{mean}10 cm G = 12.m^2/ha Thinning intensity = 15%
Medium	Thinning 1	A = 30-60 N_{seed} = 730 stem/ha, D_{mean} 17 cm N_{sprout} = 350 stem/ha D_{mean} 19 cm G =19.9m^2/ha Thinning intensity = 20%
	Thinning 2	A = 60-90 N_{seed} = 490 stem/ha. D_{mean}24cm N_{sprout} = 90 stem/ha. D_{mean} 28 cm G =19.4m^2/ha Thinning intensity = 20%
Adult mostly high oak forest	Regeneration cut shelterwood and irregular shelterwood system) 2-3 phases	A = 100 ; N = 350 stem/ha ; D_{mean} = 30cm G = 24.7 m^2/ha

<table>
<tr><td>Case study</td><td colspan="2">Bulgaria</td></tr>
<tr><td>Stand x site type</td><td colspan="2">- Even-aged coppice Turkey oak
- Soil type: xxx ; Nutrients (poor, average, high): xxx ; Water(low, average, high): xxx, nutrients – average, water – low</td></tr>
<tr><td>Management alternative</td><td colspan="2">No.: 12
BAUM/AM: AM
System: Even-aged shelter, irregular shelter
Regeneration: natural – seed and sprout
Thinning type (below, above): above
Thinning intensity (weak, average, heavy): weak
Entry interval: .5-10
Addressed climate change effect:drought, more frequent forest fires
Adaptation strategy (B, RI, AC): AC, RI
Expected level for addressed objectives (low, average, high):
timber production (average), carbon sequestration (average), biodiversity (average)</td></tr>
<tr><td>Phase of development</td><td>Process</td><td>Description</td></tr>
<tr><td>Adult coppice</td><td>Regeneration cut – (transformation cut) coppice to be transformed into high, shelter, irregular shelter</td><td>A = 40 - Maximum rotation age
N = 1950 stems/ha
D_{mean} = 12cm
G = 15.4 m^2/ha</td></tr>
<tr><td>Regeneration</td><td>➢ species composition
➢ seed
➢ sprout
➢ afforest.</td><td>Turkey oak. 10, (Q.pubescens, Fraxinus ornus, Carpinus betulus, Carpinus orientalis)
50% seed
50% sprout
10-15%(Q.cerris, Q. pubescens, cedar)</td></tr>
<tr><td>Young</td><td>Tending</td><td>A (age) = 0-15
H = 3.7 m
75% seed.
25% sprout</td></tr>
<tr><td></td><td>Tending 2</td><td>A = 15-25
N_{seed} = 2130 stem/ha, D_{mean} 6 cm
N_{sprout}= 1150 stem/ha D_{mean}7 cm
G = 10.5.m^2/ha
Thinning intensity = 10%</td></tr>
<tr><td>Medium</td><td>Thinning 1</td><td>A = 25-40
N_{seed} = 1360 stem/ha, D_{mean} 10 cm
N_{sprout} = 690 stem/ha D_{mean} 12 cm
G =13.8m^2/ha
Thinning intensity = 15%</td></tr>
<tr><td></td><td>Thinning 2</td><td>A = 40-70
N_{seed} = 880 stem/ha. D_{mean}14cm
N_{sprout} = 320 stem/ha. D_{mean} 16 cm
G =14.1 m^2/ha
Thinning intensity = 15%</td></tr>
<tr><td>Adult mostly high oak forest</td><td>Regeneration cut shelterwood and irregular shelterwood system)
2-3 phases</td><td>A = 80
N = 620 stem/ha
D_{mean} = 18cm
G = 15.7 m^2/ha</td></tr>
</table>

Continental Romania case (5b)

- This results from compiling information about the management rules, production tables and a deep knowledge of the silviculture practices, which makes the management options very realistic.

General presentation of forests state from FRASIN forest district

Stand type		Area	
Code	Name	ha	%
0	Other lands	310,4	2,6
11	Pure Norway spruce stands	115,9	1,0
12	**Mixed Norway spruce and silver fir stands**	**3180,5**	**27,1**
13	**Mixed Norway spruce, silver fir and beech stands**	**6714,5**	**57,2**
14	Mixed Norway spruce and beech stands	235,9	2,0
21	Pure silver fir stands	31,4	0,3
22	Mixed Silver fir and beech stands	114,8	1,0
41	Pure mountainous beech stands	1038,5	8,8
97	Aspen stands	0,6	0,0
Total general		11742,5	100,0

In consequence the following stand types were chose:

- **Norway spruce and silver fir stands;**
- **Mixed Norway spruce, silver fir and beech stands.**

With respect to forest structure the following cases were chose:

Stand type	%		
	Even-aged	Uneven-aged	Total
Mixed Norway spruce and silver fir stands	**77,1**	22,9	100,0
Mixed Norway spruce, silver fir and beech stands	**58,0**	**42,0**	100,0

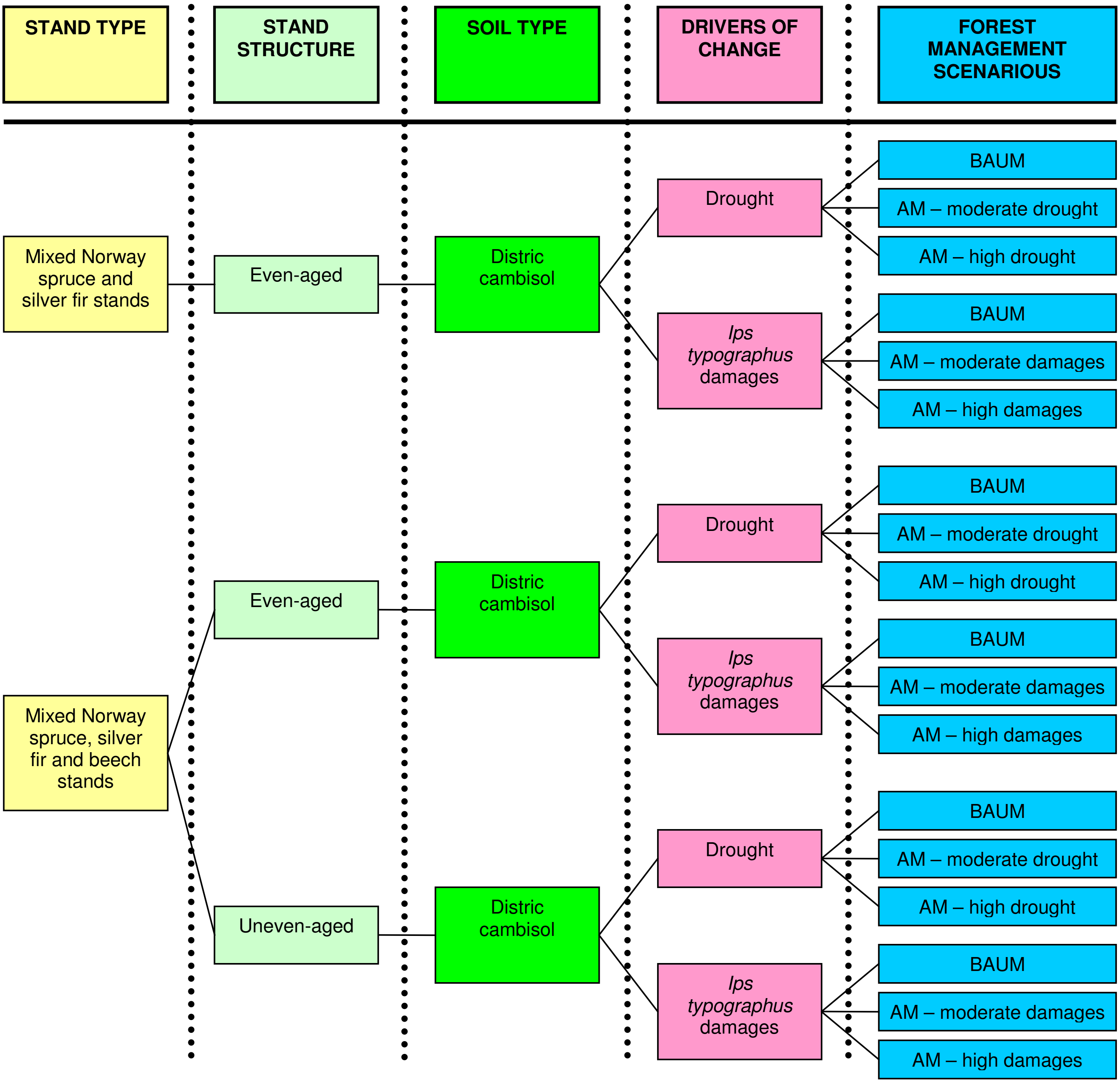
In terms of soil (site) condition

Stand type	Stand structure	Soil type (%)						Total
		Luvisol	Eutric cambisol	**Distric cambisol**	Spodisol	Gleysol	Technosol	
Norway spruce and silver fir stands	Even-aged	21,5	3,8	**72,2**	2,6	0,0	0,0	100,0
Mixed Norway spruce, silver fir and beech stands	Even-aged	14,0	7,5	**78,4**	0,0	0,0	0,1	100,0
	Uneven/aged	22,3	12,7	**64,9**	0,0	0,0	0,2	100,0

Due to the high percentage of district cambisols compared with the other soil types used by the two selected stand types, we considered it as the main soil type in Frasin forest district. Therefore, for Frasin forest district, we will run the LandCLIM model using a single soil type: **district cambisol**.
In terms of nutrients, and water content it might be described as it follows:

- **Nutrients** content and availability: **average**;
- **Water** holding capacity and availability: **high**.

The main drivers of change in forest resource are climate change (more drought), and insect damages (*Ips typographus*).


STAND TYPE
STAND STRUCTURE
SOIL TYPE
DRIVERS OF CHANGE
FOREST MANAGEMENT SCENARIOUS
Mixed Norway spruce and silver fir stands
Even-aged
Distric cambisol
Drought
BAUM
AM – moderate drought
AM – high drought
Ips typographus damages
BAUM
AM – moderate damages
AM – high damages
Mixed Norway spruce, silver fir and beech stands
Even-aged
Distric cambisol
Drought
BAUM
AM – moderate drought
AM – high drought
Ips typographus damages
BAUM
AM – moderate damages
AM – high damages
Uneven-aged
Distric cambisol
Drought
BAUM
AM – moderate drought
AM – high drought
Ips typographus damages
BAUM
AM – moderate damages
AM – high damages

The modified variables and values are presented in bold red.

Case study	Case Continental, the Northern Carpathian Mountains, Romania: FRASIN	
Stand x site type	- Even-aged mixed Norway spruce and silver fir stands - Soil type: district cambisol ; Nutrients[10] (poor, average, high): average ; Water[1] (low, average, high): high	
Management alternative	**No.: 1** **BAUM/AM: BAUM** **System**: Even-aged shelter. **Regeneration:** natural **Thinning type (below, above):** combined (about 60% below and 40 % above) **Thinning intensity (weak, average, heavy):** average **Entry interval:** 10 years **Addressed climate change effect**:N/A **Adaptation strategy (B, RI, AC)**: N/A **Expected level for addressed objectives (low, average, high)**: Net primary production (high), soil protection (average), biodiversity (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Around 10000-15000 trees/ha, H_{dom}=4m (dominant height) at 10 yr
Young	Tending	D_{dom} (dominant diameter) >= 5cm: tending to 6000 stems/ha
Medium	Thinning 1	$D_{dom} \geq 10$ cm: Thinning to 3600 stems/ha
	Thinning 2	$D_{dom} \geq 15$ cm: Thinning to 2100 stems/ha
	Thinning 3	$D_{dom} \geq 20$ cm: Thinning to 1460 stems/ha
	Thinning 4	$D_{dom} \geq 25$ cm: Thinning to 1030 stems/ha
	Thinning 5	$D_{dom} \geq 30$ cm: Thinning to 840 stems/ha
Adult	Regeneration cut (if shelterwood system)	$D_{dom} \geq 40$ cm: Thinning to 280 stems/ha
	Final cut (if shelterwood system)	Around 140 stems/ha at $D_{dom} \geq 45$ cm, Maximum rotation age 120 yr
Short description: BAUM management schedulefor a mixed even-aged stand with Norway spruce and silver fir of good productivity in Romania (low mountain forests). The main objective is timber production but soil protection is also considered. Thinning intensity is medium and trees are harvested both from below and within the top canopy layer in order to maintain a good sanitary state but also to obtain good quality trees.		

[10] "Nutrients" refers to (content x availability); "Water" refers to (holding capacity x availability)

Case study	**Case Continental, the Northern Carpathian Mountains, Romania: FRASIN**	
Stand x site type	- Even-aged mixed Norway spruce and silver fir stands - **S**oil type: district cambisol ; Nutrients (poor, average, high): average ; Water(low, average, high): high	
Management alternative	**No.: 2** **BAUM/AM: AM** **System**: Even-aged shelter. **Regeneration:** natural **Thinning type (below, above):above** **Thinning intensity (weak, average, heavy): weak-average** **Entry interval:** 10 years **Addressed climate change effect**: **moderate drought** **Adaptation strategy (B, RI, AC)**: **B, RI** **Expected level for addressed objectives (low, average, high)**: Net primary production (high), soil protection (**average-low**), biodiversity (**low-moderate**)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Around 10000-15000 trees/ha, H_{dom}=4m (dominant height) at 10 yr
Young	Tending	D_{dom} (dominant diameter) >= 5cm: tending to 6000 stems/ha
Medium	Thinning 1	$D_{dom} \geq$ 10 cm: Thinning to **3900 stems/ha**
	Thinning 2	$D_{dom} \geq$ 15 cm: Thinning to **2800 stems/ha**
	Thinning 3	$D_{dom} \geq$ 20 cm: Thinning to **1900 stems/ha**
	Thinning 4	$D_{dom} \geq$ 25 cm: Thinning to **1500 stems/ha**
	Thinning 5	$D_{dom} \geq$ 30 cm: Thinning to **1200 stems/ha**
Adult	Regeneration cut (if shelterwood system)	$D_{dom} \geq$ 40 cm: Thinning to **400 stems/ha**
	Final cut (if shelterwood system)	Around **200 stems/ha** at $D_{dom} \geq$ 45 cm, Maximum rotation age **110 yr**

Short description: Moderate drought is expected to affect the forests. Silver fir and Noway spruce trees should adapt to these conditions if stand density is regulated for **RI** and the trees are adapted for **B**. So it was considered necessary to **reduce thinning intensity** in order to decrease the level of water evaporation from soil (the above thinning are suggested to extract the bigger trees whose level of evapo-transpiration is higher). The **maximum rotation age was reduce to 110 yr**. to avoid the apparition of a large number of standing dead trees that might increase the fire risk. As a possibility of **B** it might be considered that some xerophyte tree species could appear in this mountain region coming from lower altitudes so, the **biodiversity level will be increase**.

Case study	**Case Continental, the Northern Carpathian Mountains, Romania: FRASIN**	
Stand x site type	- Even-aged mixed Norway spruce and silver fir stands - **S**oil type: district cambisol ; Nutrients (poor, average, high): average ; Water[1] (low, average, high): high	
Management alternative	**No.: 3** **BAUM/AM: AM** **System**: Even-aged shelter. **Regeneration:** natural **Thinning type (below, above):above** **Thinning intensity (weak, average, heavy): weak** **Entry interval:** 10 years **Addressed climate change effect**: **high drought** **Adaptation strategy (B, RI, AC)**: **B, RI, AC** **Expected level for addressed objectives (low, average, high)**: Net primary production (**high-moderate**), soil protection (**low**), biodiversity (**moderate**)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Around 10000-15000 trees/ha, H_{dom}=4m (dominant height) at 10 yr
Young	Tending	D_{dom} (dominant diameter) >= 5cm: tending to 6000 stems/ha
Medium	Thinning 1	D_{dom} ≥ 10 cm: Thinning to **4200 stems/ha**
	Thinning 2	D_{dom} ≥ 15 cm: Thinning to **3300 stems/ha**
	Thinning 3	D_{dom} ≥ 20 cm: Thinning to **2300 stems/ha**
	Thinning 4	D_{dom} ≥ 25 cm: Thinning to **1800 stems/ha**
	Thinning 5	D_{dom} ≥ 30 cm: Thinning to **1300 stems/ha**
	Thinning 6	**D_{dom} ≥ 35 cm: Thinning to 900 stems/ha**
Adult	Regeneration cut (if shelterwood system)	D_{dom} ≥ 40 cm: Thinning to **500 stems/ha**
	Final cut (if shelterwood system)	Around **250 stems/ha** at D_{dom} ≥ 45 cm, Maximum rotation age **100 yr**

Short description: High drought is expected to affect the forests. Silver fir and Noway spruce trees should adapt to these conditions if stand density is regulated for **RI** and the trees are adapted for **B** and **AC**. It was considered necessary to **reduce more the thinning intensity** in order to decrease the level of water evaporation from soil (the above thinning are suggested to extract the bigger trees whose level of evapo-transpiration is higher). The **maximum rotation age was reducing to 100 yr**. As a possibility of **B** it might be considered that more xerophyte tree species could appear in this region coming from lower altitudes and the **biodiversity level will be moderate**.

Case study	Case Continental, the Northern Carpathian Mountains, Romania: FRASIN	
Stand x site type	- Even-aged mixed Norway spruce and silver fir stands - Soil type: district cambisol ; Nutrients (poor, average, high): average ; Water[1] (low, average, high): high	
Management alternative	**No.: 1** **BAUM/AM: BAUM** **System**: Even-aged shelter. **Regeneration:** natural **Thinning type (below, above):** combined (about 60% below and 40 % above) **Thinning intensity (weak, average, heavy):** average **Entry interval:** 10 years **Addressed climate change effect**: N/A **Adaptation strategy (B, RI, AC)**: N/A **Expected level for addressed objectives (low, average, high)**: Net primary production (high), soil protection (average), biodiversity (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Around 10000-15000 trees/ha, H_{dom}=4m (dominant height) at 10 yr
Young	Tending	D_{dom} (dominant diameter) >= 5cm: tending to 6000 stems/ha
Medium	Thinning 1	$D_{dom} \geq 10$ cm: Thinning to 3600 stems/ha
	Thinning 2	$D_{dom} \geq 15$ cm: Thinning to 2100 stems/ha
	Thinning 3	$D_{dom} \geq 20$ cm: Thinning to 1460 stems/ha
	Thinning 4	$D_{dom} \geq 25$ cm: Thinning to 1030 stems/ha
	Thinning 5	$D_{dom} \geq 30$ cm: Thinning to 840 stems/ha
Adult	Regeneration cut (if shelterwood system)	$D_{dom} \geq 40$ cm: Thinning to 280 stems/ha
	Final cut (if shelterwood system)	Around 140 stems/ha at $D_{dom} \geq 45$ cm, Maximum rotation age 120 yr
Short description: BAUM management schedulefor a mixed even-aged stand with Norway spruce and silver fir of good productivity in Romania (low mountain forests). The main objective is timber production but soil protection is also considered. Thinning intensity is medium and trees are harvested both from below and within the top canopy layer in order to maintain a good sanitary state but also to obtain good quality trees.		

Case study	Case Continental, the Northern Carpathian Mountains, Romania: FRASIN	
Stand x site type	- Even-aged mixed Norway spruce and silver fir stands - Soil type: district cambisol ; Nutrients (poor, average, high): average ; Water[1] (low, average, high): high	
Management alternative	**No.: 2** **BAUM/AM: AM** **System**: Even-aged shelter. **Regeneration:** natural **Thinning type (below, above):below** **Thinning intensity (weak, average, heavy):** average **Entry interval:** 10 years **Addressed climate change effect**: **moderate *Ips typographus* damages** **Adaptation strategy (B, RI, AC)**: **B, RI** **Expected level for addressed objectives (low, average, high)**: Net primary production (**high-moderate**), soil protection (average), biodiversity (**moderate**)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Around 10000-15000 trees/ha, H_{dom}=4m (dominant height) at 10 yr
Young	Tending	D_{dom} (dominant diameter) >= 5cm: tending to 6000 stems/ha
Medium	Thinning 1	$D_{dom} \geq 10$ cm: Thinning to 3600 stems/ha
	Thinning 2	$D_{dom} \geq 15$ cm: Thinning to 2100 stems/ha
	Thinning 3	$D_{dom} \geq 20$ cm: Thinning to 1460 stems/ha
	Thinning 4	$D_{dom} \geq 25$ cm: Thinning to 1030 stems/ha
	Thinning 5	$D_{dom} \geq 30$ cm: Thinning to 840 stems/ha
Adult	Regeneration cut (if shelterwood system)	$D_{dom} \geq 40$ cm: Thinning to 280 stems/ha
	Final cut (if shelterwood system)	Around 140 stems/ha at $D_{dom} \geq 45$ cm, Maximum rotation age 120 yr

Short description: **moderate *Ips typographus* damages** are expected to affect the forests. Noway spruce trees should adapt to these conditions if stand composition is regulated for **RI** and the trees are adapted for **B**. It might be an option **to reduce the Norway spruce proportion in stand composition** in order to decrease the risk of damages. As a possibility of **B** it might be considered that other tree species can be introduce in stands composition and the **biodiversity level will be moderate**. At this point the thinning intensity can be maintain as moderate, but **below thinning** are more indicated to eliminate the damaged trees.

Case study	**Case Continental, the Northern Carpathian Mountains, Romania: FRASIN**	
Stand x site type	- Even-aged mixed Norway spruce and silver fir stands - **S**oil type: district cambisol ; Nutrients (poor, average, high): average ; Water[1] (low, average, high): high	
Management alternative	**No.: 3** **BAUM/AM: AM** **System**: Even-aged shelter. **Regeneration:** natural **Thinning type (below, above):below** **Thinning intensity (weak, average, heavy): average-heavy** **Entry interval:** 10 years **Addressed climate change effect**: **high *Ips typographus* damages** **Adaptation strategy (B, RI, AC)**: **B, RI, AC** **Expected level for addressed objectives (low, average, high)**: Net primary production (**moderate**), soil protection (**average-low**), biodiversity (**moderate-high**)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Around 10000-15000 trees/ha, H_{dom}=4m (dominant height) at 10 yr
Young	Tending	D_{dom} (dominant diameter) >= 5cm: tending to 6000 stems/ha
Medium	Thinning 1	D_{dom} ≥ 10 cm: Thinning to **3000 stems/ha**
	Thinning 2	D_{dom} ≥ 15 cm: Thinning to **1700 stems/ha**
	Thinning 3	D_{dom} ≥ 20 cm: Thinning to **1200 stems/ha**
	Thinning 4	D_{dom} ≥ 25 cm: Thinning to **900 stems/ha**
	Thinning 5	D_{dom} ≥ 30 cm: Thinning to **700 stems/ha**
Adult	Regeneration cut (if shelterwood system)	D_{dom} ≥ 40 cm: Thinning to 280 stems/ha
	Final cut (if shelterwood system)	Around 140 stems/ha at D_{dom} ≥ 45 cm, Maximum rotation age 120 yr

Short description: heavy *Ips typographus* damages are expected to affect the forests. Noway spruce trees should adapt to these conditions if stand composition is regulated for **RI**. It might be an option **to reduce the Norway spruce proportion in stand composition** in order to decrease the risk of damages. As a possibility of **Band AC** it might be considered that other tree species can be introduce in stands composition and the **biodiversity level will be moderate-high**. The thinning intensity can be increased: **average-heavy**, and **below thinning** are indicated to eliminate the damaged trees.

Case study	**Case Continental, the Northern Carpathian Mountains, Romania: FRASIN**	
Stand x site type	- Even-aged mixed Norway spruce, silver fir and beech stands - **S**oil type: district cambisol ; Nutrients (poor, average, high): average ; Water[1] (low, average, high): high	
Management alternative	**No.: 1** **BAUM/AM: BAUM** **System**: Even-aged shelter. **Regeneration:** natural **Thinning type (below, above):** combined (about 60% below and 40 % above) **Thinning intensity (weak, average, heavy):** average **Entry interval:** 10 years **Addressed climate change effect**: N/A **Adaptation strategy (B, RI, AC)**: N/A **Expected level for addressed objectives (low, average, high)**: Net primary production (high), soil protection (average), biodiversity (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Around 15000-20000 trees/ha, H_{dom}=4.5 m (dominant height) at 10 yr
Young	Tending	D_{dom} (dominant diameter) >= 5 cm: tending to 6000 stems/ha
Medium	Thinning 1	$D_{dom} \geq 10$ cm: Thinning to 3300 stems/ha
	Thinning 2	$D_{dom} \geq 15$ cm: Thinning to 1950 stems/ha
	Thinning 3	$D_{dom} \geq 20$ cm: Thinning to 1320 stems/ha
	Thinning 4	$D_{dom} \geq 25$ cm: Thinning to 930 stems/ha
	Thinning 5	$D_{dom} \geq 30$ cm: Thinning to 730 stems/ha
Adult	Regeneration cut (if shelterwood system)	$D_{dom} \geq 40$ cm: Thinning to 300 stems/ha
	Final cut (if shelterwood system)	Around 150 stems/ha at $D_{dom} \geq 45$ cm, Maximum rotation age 120 yr
Short description: BAUM management schedulefor a mixed even-aged stand with Norway spruce, silver fir and beech of good productivity in Romania (low mountain forests). The main objective is timber production but soil protection is also considered. Thinning intensity is medium and trees are harvested both from below and above in order to maintain a good sanitary state but also to obtain good quality trees.		

Case study	Case Continental, the Northern Carpathian Mountains, Romania: FRASIN	
Stand x site type	- Even-aged mixed Norway spruce, silver fir and beech stands - Soil type: district cambisol ; Nutrients (poor, average, high): average ; Water[1] (low, average, high): high	
Management alternative	**No.: 2** **BAUM/AM: AM** **System**: Even-aged shelter. **Regeneration:** natural **Thinning type (below, above):above** **Thinning intensity (weak, average, heavy): weak-average** **Entry interval:** 10 years **Addressed climate change effect**: **moderate drought** **Adaptation strategy (B, RI, AC)**: **B, RI** **Expected level for addressed objectives (low, average, high)**: Net primary production (high), soil protection (**average-low**), biodiversity (**low-moderate**)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Around 15000-20000 trees/ha, H_{dom}=4.5 m (dominant height) at 10 yr
Young	Tending	D_{dom} (dominant diameter) >= 5 cm: tending to 6000 stems/ha
Medium	Thinning 1	D_{dom} ≥ 10 cm: Thinning to **3800 stems/ha**
	Thinning 2	D_{dom} ≥ 15 cm: Thinning to **2400 stems/ha**
	Thinning 3	D_{dom} ≥ 20 cm: Thinning to **1600 stems/ha**
	Thinning 4	D_{dom} ≥ 25 cm: Thinning to **1150 stems/ha**
	Thinning 5	D_{dom} ≥ 30 cm: Thinning to **900 stems/ha**
Adult	Regeneration cut (if shelterwood system)	D_{dom} ≥ 40 cm: Thinning to **400 stems/ha**
	Final cut (if shelterwood system)	Around **200 stems/ha** at D_{dom} ≥ 45 cm, Maximum rotation age **110 yr**

Short description: Moderate drought is expected to affect the forests. Silver fir, Noway spruce and beech trees should adapt to these conditions if stand density is regulated for **RI** and the trees are adapted for **B**. So it was considered necessary to **reduce thinning intensity** in order to decrease the level of water evaporation from soil (the above thinning are suggested to extract the bigger trees whose level of evapo-transpiration is higher). The **maximum rotation age was reduce to 110 yr**. to avoid the apparition of a large number of standing dead trees that might increase the fire risk. As a possibility of **B** it might be considered that some xerophyte tree species will appear in this mountain region coming from lower altitudes so, the **biodiversity level will increase**.

Case study	**Case Continental, the Northern Carpathian Mountains, Romania: FRASIN**	
Stand x site type	- Even-aged mixed Norway spruce, silver fir and beech stands - **S**oil type: district cambisol ; Nutrients (poor, average, high): average ; Water[1] (low, average, high): high	
Management alternative	**No.: 3** **BAUM/AM: AM** **System**: Even-aged shelter. **Regeneration:** natural **Thinning type (below, above):above** **Thinning intensity (weak, average, heavy): weak** **Entry interval:** 10 years **Addressed climate change effect**: **high drought** **Adaptation strategy (B, RI, AC)**: **B, RI, AC** **Expected level for addressed objectives (low, average, high)**: Net primary production (**high-moderate**), soil protection (**low**), biodiversity (**moderate**)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Around 15000-20000 trees/ha, H_{dom}=4.5 m (dominant height) at 10 yr
Young	Tending	D_{dom} (dominant diameter) >= 5 cm: tending to 6000 stems/ha
Medium	Thinning 1	D_{dom} ≥ 10 cm: Thinning to **4200 stems/ha**
	Thinning 2	D_{dom} ≥ 15 cm: Thinning to **2800 stems/ha**
	Thinning 3	D_{dom} ≥ 20 cm: Thinning to **1900 stems/ha**
	Thinning 4	D_{dom} ≥ 25 cm: Thinning to **1400 stems/ha**
	Thinning 5	D_{dom} ≥ 30 cm: Thinning to **1100 stems/ha**
Adult	Regeneration cut (if shelterwood system)	D_{dom} ≥ 40 cm: Thinning to **500 stems/ha**
	Final cut (if shelterwood system)	Around **250 stems/ha** at D_{dom} ≥ 45 cm, Maximum rotation age **100 yr**

Short description: High drought is expected to affect the forests. Silver fir, Noway spruce and beech trees should adapt to these conditions if stand density is regulated for **RI** and the trees are adapted for **B** and **AC**. It was considered necessary to **reduce more the thinning intensity** in order to decrease the level of water evaporation from soil (the above thinning are suggested to extract the bigger trees whose level of evapo-transpiration is higher). The **maximum rotation age was reducing to 100 yr**. As a possibility of **B** it might be considered that more xerophyte tree species will appear in this region coming from lower altitudes and the **biodiversity level will be moderate**.

Case study	**Case Continental, the Northern Carpathian Mountains, Romania: FRASIN**	
Stand x site type	- Even-aged mixed Norway spruce, silver fir and beech stands - **S**oil type: district cambisol ; Nutrients (poor, average, high): average ; Water[1] (low, average, high): high	
Management alternative	**No.:** 1 **BAUM/AM: BAUM** **System**: Even-aged shelter. **Regeneration:** natural **Thinning type (below, above):** combined (about 60% below and 40 % above) **Thinning intensity (weak, average, heavy):** average **Entry interval:** 10 years **Addressed climate change effect**: N/A **Adaptation strategy (B, RI, AC)**: N/A **Expected level for addressed objectives (low, average, high)**: Net primary production (high), soil protection (average), biodiversity (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Around 15000-20000 trees/ha, H_{dom}=4.5 m (dominant height) at 10 yr
Young	Tending	D_{dom} (dominant diameter) >= 5 cm: tending to 6000 stems/ha
Medium	Thinning 1	$D_{dom} \geq$ 10 cm: Thinning to 3300 stems/ha
	Thinning 2	$D_{dom} \geq$ 15 cm: Thinning to 1950 stems/ha
	Thinning 3	$D_{dom} \geq$ 20 cm: Thinning to 1320 stems/ha
	Thinning 4	$D_{dom} \geq$ 25 cm: Thinning to 930 stems/ha
	Thinning 5	$D_{dom} \geq$ 30 cm: Thinning to 730 stems/ha
Adult	Regeneration cut (if shelterwood system)	$D_{dom} \geq$ 40 cm: Thinning to 300 stems/ha
	Final cut (if shelterwood system)	Around 150 stems/ha at $D_{dom} \geq$ 45 cm, Maximum rotation age 120 yr
Short description: BAUM management schedulefor a mixed even-aged stand with Norway spruce, silver fir and beech of good productivity in Romania (low mountain forests). The main objective is timber production but soil protection is also considered. Thinning intensity is medium and trees are harvested both from below and above in order to maintain a good sanitary state but also to obtain good quality trees.		

Case study	**Case Continental, the Northern Carpathian Mountains, Romania: FRASIN**	
Stand x site type	- Even-aged mixed Norway spruce, silver fir and beech stands - **S**oil type: district cambisol ; Nutrients (poor, average, high): average ; Water[1] (low, average, high): high	
Management alternative	**No.: 2** **BAUM/AM: AM** **System**: Even-aged shelter. **Regeneration:** natural **Thinning type (below, above):below** **Thinning intensity (weak, average, heavy):** average **Entry interval:** 10 years **Addressed climate change effect**: **moderate *Ips typographus* damages** **Adaptation strategy (B, RI, AC)**: **B, RI** **Expected level for addressed objectives (low, average, high)**: Net primary production (**high-moderate**), soil protection (average), biodiversity (**moderate**)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Around 15000-20000 trees/ha, H_{dom}=4.5 m (dominant height) at 10 yr
Young	Tending	D_{dom} (dominant diameter) >= 5 cm: tending to 6000 stems/ha
Medium	Thinning 1	$D_{dom} \geq 10$ cm: Thinning to 3300 stems/ha
	Thinning 2	$D_{dom} \geq 15$ cm: Thinning to 1950 stems/ha
	Thinning 3	$D_{dom} \geq 20$ cm: Thinning to 1320 stems/ha
	Thinning 4	$D_{dom} \geq 25$ cm: Thinning to 930 stems/ha
	Thinning 5	$D_{dom} \geq 30$ cm: Thinning to 730 stems/ha
Adult	Regeneration cut (if shelterwood system)	$D_{dom} \geq 40$ cm: Thinning to 300 stems/ha
	Final cut (if shelterwood system)	Around 150 stems/ha at $D_{dom} \geq 45$ cm, Maximum rotation age 120 yr

Short description: moderate *Ips typographus* damages are expected to affect the forests. Noway spruce trees should adapt to these conditions if stand composition is regulated for **RI** and the trees are adapted for **B**. It might be an option **to reduce the Norway spruce proportion in stand composition** in order to decrease the risk of damages. As a possibility of **B** it might be considered that other tree species can be introduce in stands composition and the **biodiversity level will be moderate**. At this point the thinning intensity can be maintain as moderate, but **below thinning** are more indicated to eliminate the damaged trees.

Case study	**Case Continental, the Northern Carpathian Mountains, Romania: FRASIN**	
Stand x site type	- Even-aged mixed Norway spruce, silver fir and beech stands - **S**oil type: district cambisol ; Nutrients (poor, average, high): average ; Water[1] (low, average, high): high	
Management alternative	**No.: 3** **BAUM/AM: AM** **System**: Even-aged shelter. **Regeneration:** natural **Thinning type (below, above):below** **Thinning intensity (weak, average, heavy): average-heavy** **Entry interval:** 10 years **Addressed climate change effect**: **high *Ips typographus* damages** **Adaptation strategy (B, RI, AC)**: **B, RI, AC** **Expected level for addressed objectives (low, average, high)**: Net primary production (**moderate**), soil protection (**average-low**), biodiversity (**moderate-high**)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	Around 15000-20000 trees/ha, H_{dom}=4.5 m (dominant height) at 10 yr
Young	Tending	D_{dom} (dominant diameter) >= 5 cm: tending to 6000 stems/ha
Medium	Thinning 1	D_{dom} ≥ 10 cm: Thinning to **2900 stems/ha**
	Thinning 2	D_{dom} ≥ 15 cm: Thinning to **1700 stems/ha**
	Thinning 3	D_{dom} ≥ 20 cm: Thinning to **1150 stems/ha**
	Thinning 4	D_{dom} ≥ 25 cm: Thinning to **850 stems/ha**
	Thinning 5	D_{dom} ≥ 30 cm: Thinning to **680 stems/ha**
Adult	Regeneration cut (if shelterwood system)	D_{dom} ≥ 40 cm: Thinning to **280 stems/ha**
	Final cut (if shelterwood system)	Around **140 stems/ha** at D_{dom} ≥ 45 cm, Maximum rotation age 120 yr
Short description: **heavy *Ips typographus* damages** are expected to affect the forests. Noway spruce trees should adapt to these conditions if stand composition is regulated for **RI**. It might be an option **to reduce the Norway spruce proportion in stand composition** in order to decrease the risk of damages. As a possibility of **Band AC** it might be considered that other tree species can be introduce in stands composition and the **biodiversity level will be moderate-high**. The thinning intensity can be increased: **average-heavy**, and **below thinning** are indicated to eliminate the damaged trees.		

Case study	**Case Continental, the Northern Carpathian Mountains, Romania: FRASIN**			
Stand x site type	- Uneven-aged mixed Norway spruce, silver fir and beech stands - **S**oil type: district cambisol ; Nutrients (poor, average, high): average ; Water[1] (low, average, high): high			
Management alternative	**Nr: 1** **BAUM/ AM: BAUM** **System**: Uneven-aged **Selection cuttings intensity (weak, average, heavy):** average **Addressed climate change effect**: N/A **Adaptation strategy (B, RI, AC)**: N/A **Expected level for addressed objectives (low, average, high)**: Net primary production (high), soil protection (average), biodiversity (low)			
Cutting cycle	10 years			
Threshold basal area for management	>= 48 m^2/ha ; assuming inverse J shaped (or close to it) diameter distribution of the initial stand			
Diameter class	**10-25 cm**	**25-40 cm**	**40-55 cm**	**> 55 cm**
Harvest intensity (HI), in trees %	Norway spruce = 80 Silver fir = 85 Beech = 85	Norway spruce = 65 Silver fir = 65 Beech = 65	Norway spruce = 50 Silver fir = 50 Beech = 55	Norway spruce = 100 Silver fir = 100 Beech = 100
Short description: BAUM management regime for uneven-aged Norway spruce, silver fir and beech stands of high productivity in Northern Romania. High timber production is expected but soil protection is also considered. The harvest intensity is moderate and it was computed as percentage of trees removed from each diameter class with respect to all the trees removed from the same diameter class and from all the higher diameter classes. The considered limit diameters are 88 cm for Norway spruce and silver fir, respectively 84 cm for beech.				

Case study	**Case Continental, the Northern Carpathian Mountains, Romania: FRASIN**			
Stand x site type	- Uneven-aged mixed Norway spruce, silver fir and beech stands - **S**oil type: district cambisol ; Nutrients (poor, average, high): average ; Water[1] (low, average, high): high			
Management alternative	**Nr: 2** **BAUM/ AM: AM** **System**: Uneven-aged **Selection cuttings intensity (weak, average, heavy): weak-average** **Addressed climate change effect**: **moderate drought** **Adaptation strategy (B, RI, AC)**: **B, RI** **Expected level for addressed objectives (low, average, high)**: Net primary production (high), soil protection (**average-low**), biodiversity (**low-moderate**)			
Cutting cycle	10 years			
Threshold basal area for management	>= **42 m^2/ha** ; assuming inverse J shaped (or close to it) diameter distribution of the initial stand			
Diameter class	**10-25 cm**	**25-40 cm**	**40-55 cm**	**> 55 cm**
Harvest intensity (HI), in trees %	Norway spruce = **70** Silver fir = **78** Beech = **78**	Norway spruce = **58** Silver fir = **58** Beech = **58**	Norway spruce = **45** Silver fir = **45** Beech = **48**	Norway spruce = 100 Silver fir = 100 Beech = 100

Short description: Moderate drought is expected to affect the forests. High timber production is expected but soil protection is also considered. Silver fir, Noway spruce and beech trees should adapt to these conditions if stand density is regulated for **RI** and the trees are adapted for **B**. So it was considered necessary to **reduce cutting intensity** in order to decrease the level of water evaporation from soil. The **limit diameter was reduced to 80 cm for Norway spruce and silver fir and to 76 cm for beech** to avoid the apparition of a large number of standing dead trees that might increase the fire risk. As a possibility of **B** it might be considered that some xerophyte tree species will appear in this mountain region coming from lower altitudes so, the **biodiversity level will increase**.

Case study	**Case Continental, the Northern Carpathian Mountains, Romania: FRASIN**			
Stand x site type	- Uneven-aged mixed Norway spruce, silver fir and beech stands - **S**oil type: district cambisol ; Nutrients (poor, average, high): average ; Water[1] (low, average, high): high			
Management alternative	**Nr: 3** **BAUM/ AM: AM** **System**: Uneven-aged **Selection cuttings intensity (weak, average, heavy): weak** **Addressed climate change effect**: **high drought** **Adaptation strategy (B, RI, AC)**: **B, RI, AC** **Expected level for addressed objectives (low, average, high)**: Net primary production (**high-moderate**), soil protection (**low**), biodiversity (**moderate**)			
Cutting cycle	10 years			
Threshold basal area for management	>= **35 m^2/ha** ; assuming inverse J shaped (or close to it) diameter distribution of the initial stand			
Diameter class	**10-25 cm**	**25-40 cm**	**40-55 cm**	**> 55 cm**
Harvest intensity (HI), in trees %	Norway spruce = **60** Silver fir = **70** Beech = **70**	Norway spruce = **550** Silver fir = **50** Beech = **50**	Norway spruce = **40** Silver fir = **40** Beech = **40**	Norway spruce = 100 Silver fir = 100 Beech = 100

Mediterranean Catalonia case (4a)

Optimising Mediterranean forest stand management under climate change based on a process-based decision support tool GOTILWA++ ; by Marc Palahi and Carles Gracia

For the determination of adaptive management strategies in even-aged *P. sylvestris* stands in Catalonia we present the first attempt to optimize forest stand management in a Mediterranean context in the light of different changing climatic scenarios, considering different economic and ecological management objectives. To do so, **a new forest management decision support system was developed based on the existing process based model; GOTILWA+** (Growth of trees is limited by water in the Mediterranean). Such process based model was **expanded into a decision support system by linking it to a Particle Swarm optimization algorithm and a new interface that allows selecting among a set of management objectives, decision variables, climate scenarios and economic parameters in order to optimise the management of a given forest stand** (species, density, site conditions, etc).

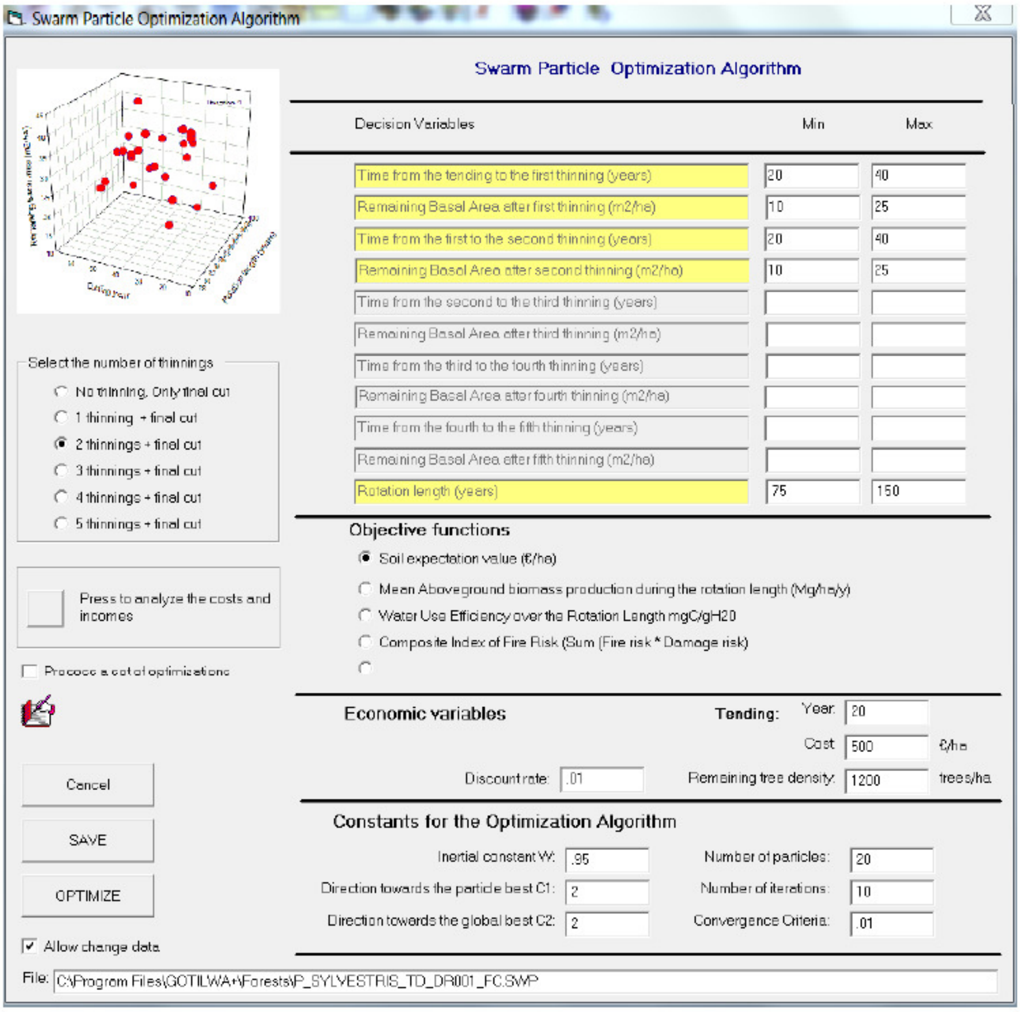
The aim of this study is to optimize the management of *P. sylvestris* stands in north-east of Spain (Catalonia) under two different climate scenarios and four different management objectives; (1) timber profitability (soil expectation value), (2) biomass production (or carbon sequestered??), (3) stand-level water use efficiency and (4) the fire risk adjusted timber profitability. These objectives cover economic, ecological and fire risk-related goals and thus by comparing their optimal management regimes important insights to improve forest management policymaking and the adaptive management of Mediterranean forests in the face of rapidly changing climatic conditions will be gained.

Type of expected Results

For two climate scenarios, for 2-4 objetive functions, and for 2 soil depths/climatic conditions

Objective variable		Soil depth 30 cm				Soil depth 120 cm			
		SEV	Biomass	F_SEV	SWUE	SEV	Biomass	F_SEV	SWUE
BAU	**SEV** R N°Thinning	X							
	Biomass R N°Thinning		X						
	Fire-risk adjusted SEV R N°Thinning			X					
	Stand Water Use Efficiency R N°Thinning				X				
Scenario 2	**SEV** R N°Thinning					X			
	Biomass R N°Thinning						X		
	Fire-risk adjusted SEV R N°Thinning							X	
	Stand water use efficiency R N°Thinning								X

Some screenshots illustrating the use of the decision support system

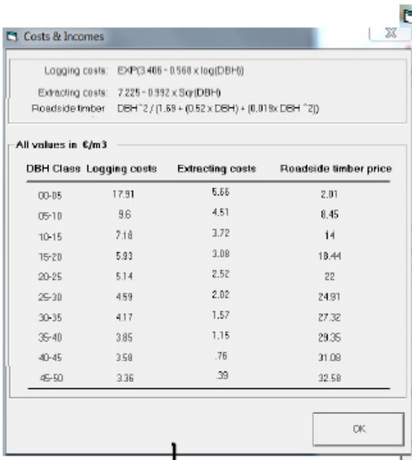


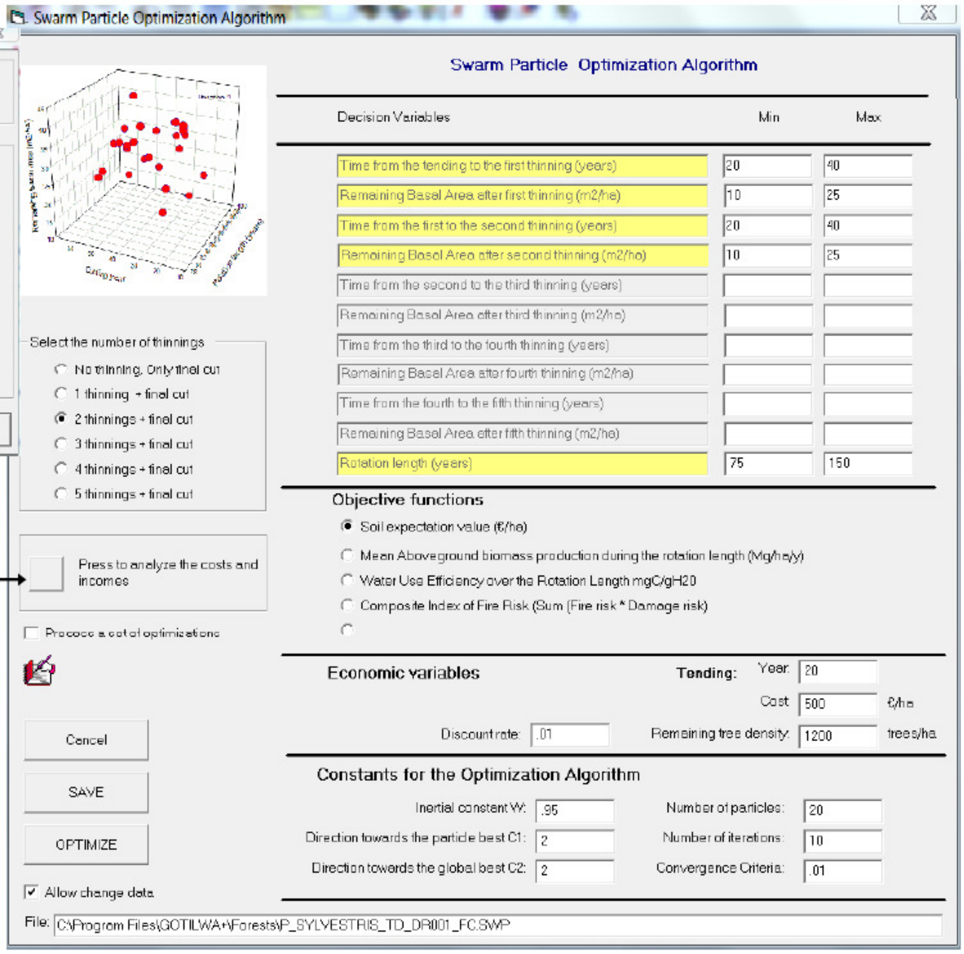
The Swarm Particle Optimization (SPO) algorithm interface .

The decision variables are : the rotation length and the time and intensity of one to five thinnings to be applied to the forest during the rotation length. The user defines a minimum and maximum treshold for each decision variable. In the example, two thinnings are explored in addition to the final thinning. The particles will move in a 5-dimensional space exploring for each point the value of the selected objective function.

Soil expectation value, biomass produced or carbon fixed over the rotation length are maximized while the water use to produce a cubic meter of wood or the risk of fire are objective functions to be minimized.

The number of particles, the number of iterations as well as the convergence criteria must be carefully considered in each particular application.





The built-in economic values of the management operations (logging and extracting costs and the roadside timber price per each DBH class) are the default costs and income values used in the analysis. These values can be modified to fit to the more realistic values of each problem analysis.

Costs & Incomes

Logging costs: EXP(3.406 - 0.568 x log(DBH))

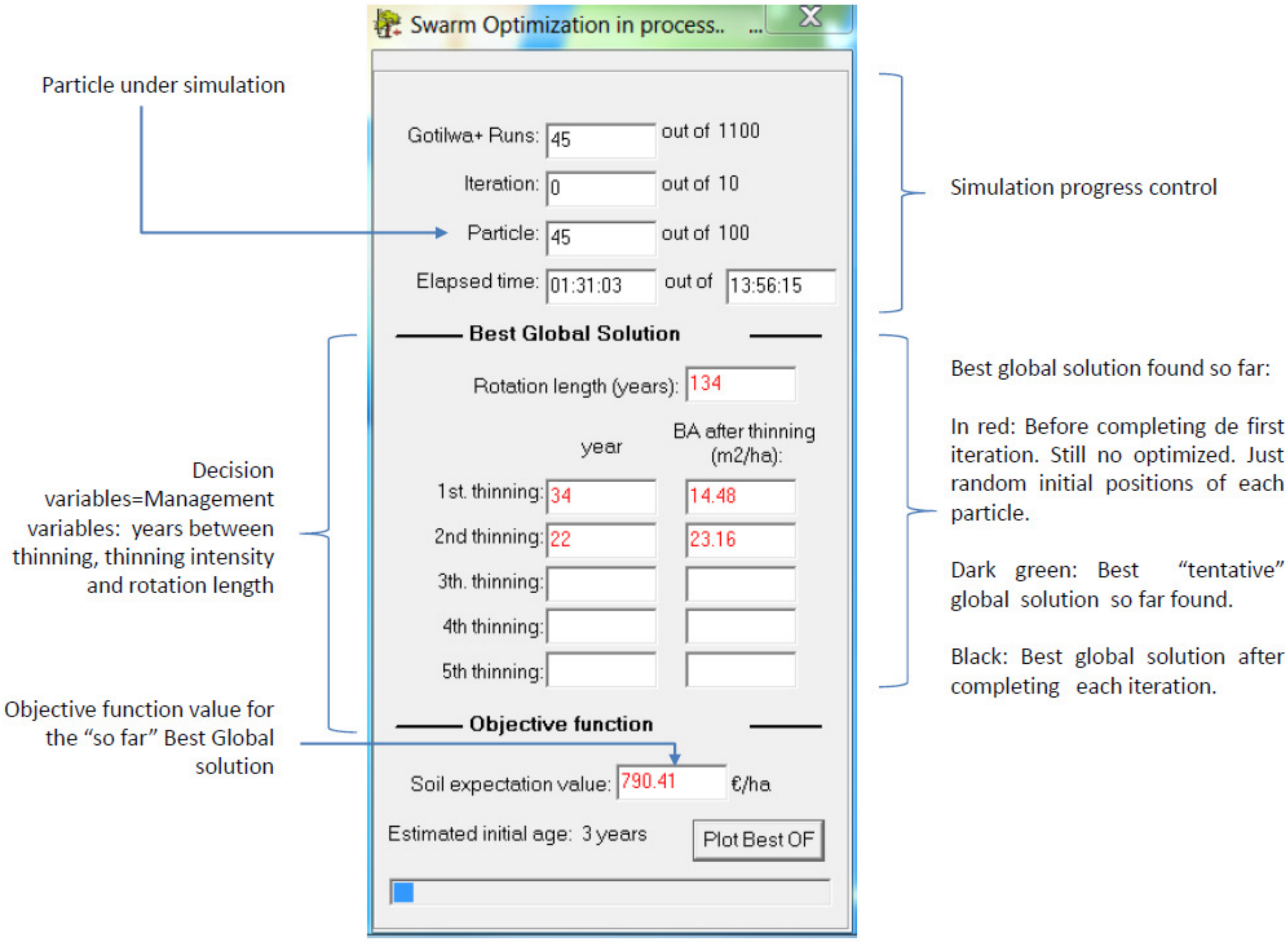
Extracting costs: 7.225 - 0.992 x Sqr(DBH)

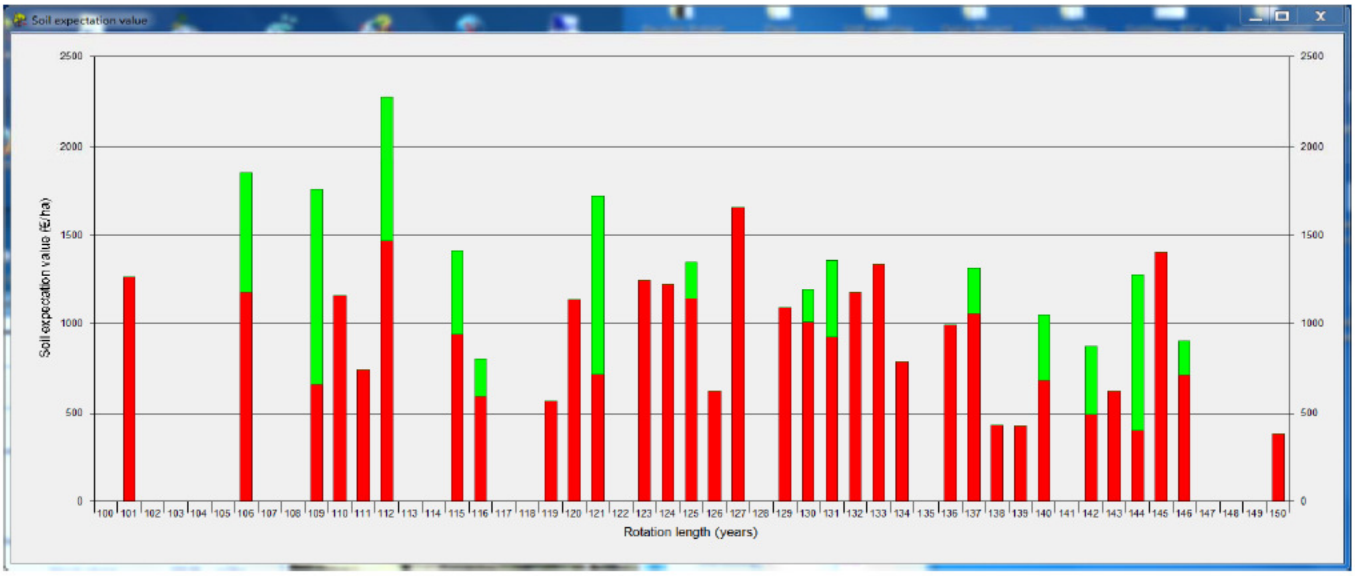
Roadside timber DBH^2 / (1.69 + (0.52 x DBH) + (0.019x DBH ^2))

All values in €/m3

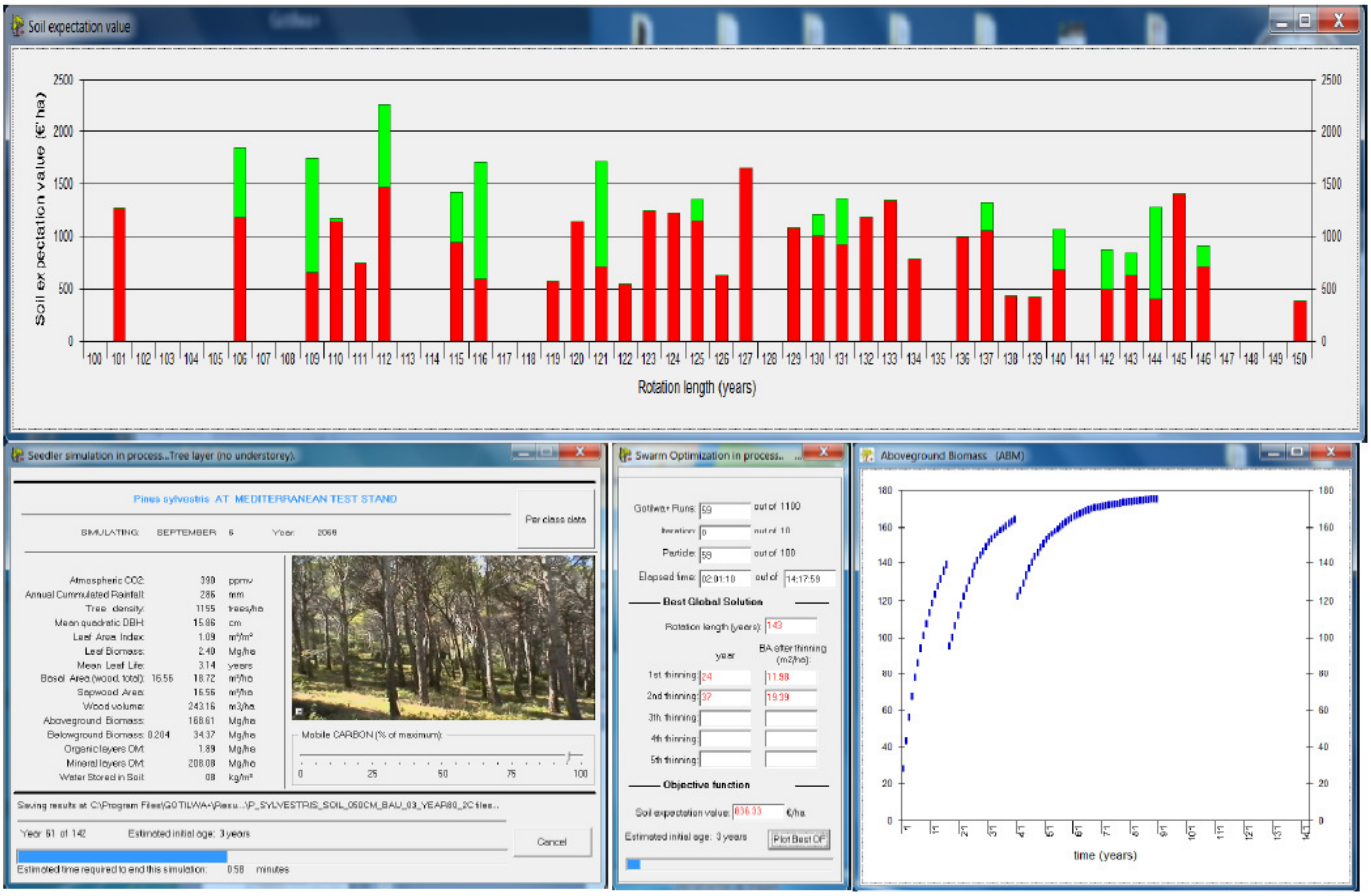
DBH Class	Logging costs	Extracting costs	Roadside timber price
00-05	17.91	5.66	2.01
05-10	9.6	4.51	8.45
10-15	7.18	3.72	14
15-20	5.93	3.08	18.44
20-25	5.14	2.52	22
25-30	4.59	2.02	24.91
30-35	4.17	1.57	27.32
35-40	3.85	1.15	29.35
40-45	3.58	.76	31.08
45-50	3.36	.39	32.58

OK

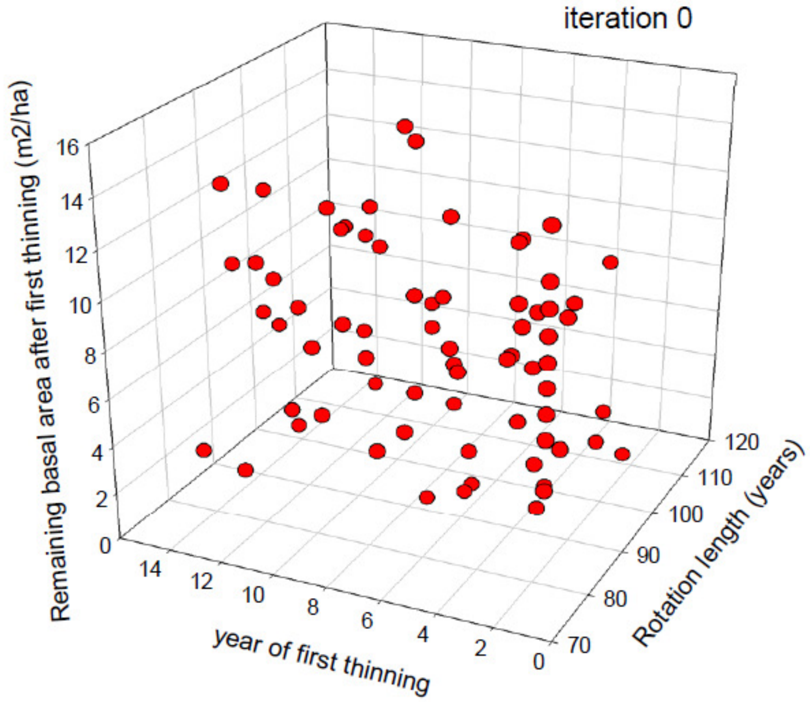

Swarm Optimization in process..
Gotilwa+ Runs: 45 out of 1100
Iteration: 0 out of 10
Particle: 45 out of 100
Elapsed time: 01:31:03 out of 13:56:15
Best Global Solution
Rotation length (years): 134
year
BA after thinning (m2/ha):
1st. thinning: 34 14.48
2nd thinning: 22 23.16
3th. thinning:
4th thinning:
5th thinning:
Objective function
Soil expectation value: 790.41 €/ha
Estimated initial age: 3 years
Plot Best OF
Particle under simulation
Simulation progress control
Decision variables=Management variables: years between thinning, thinning intensity and rotation length
Best global solution found so far:
In red: Before completing de first iteration. Still no optimized. Just random initial positions of each particle.
Dark green: Best "tentative" global solution so far found.
Black: Best global solution after completing each iteration.
Objective function value for the "so far" Best Global solution



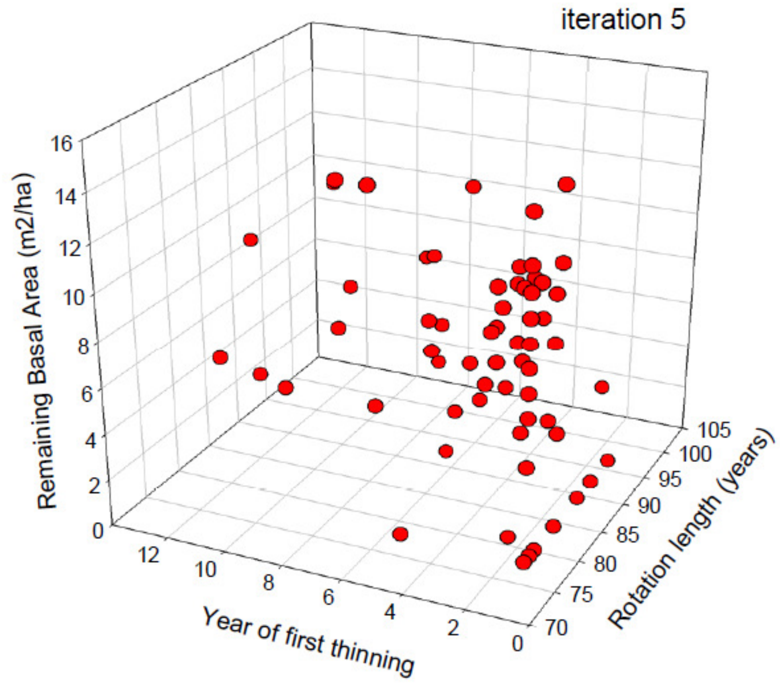
The different rotation lengths are randomly explored and the result of the objective function (in this exemple, the soil expectation value) is represented in the histogram. For each rotation length several thinnings, from none to five, can be applied and the intensity of each thinning , measured as the basal area remaining after thinning, is also randomly explored between a minimum and a maximum tresholds defined by the user. For each set of values resulting from this random exploration, the minimu and maximum values of the objective function are represented in the bars of the histogram (green colour representing the maximum value of the objective function –the one used in the optimization process- and the red colour representing the minimum value of the objective function explored so far. The so called **particle best** and **global best** values are determined for each particle and for the entire system at the end of each iteration and each particle moves according to the rules of the **swarm particle optimization algorithm** to converge to the optimal combination of decision variables which produce the optimal management (=the maximum value of the objective function).



The swarm particle optimization algorithm interface at work. The bottom left window is the GOTILWA+ process based model interface. For each set of decision variables explored , the user can track the results provided year by year for each process involved in the forest growth. The user can select one of the 77 output variables provided by Gotilwa+ to check in real time the evolution of such variable. In the example, the evolution of the aboveground biomass and the effect of the tending and the first thinning are represented in the bottom right plot. The interface is refreshed automatically during the optimization process to provide to the user a continuous track of the optimization process. In addition all the values are recorded so the user can revisit and analyze in detail the optimization process



Example of the evolution of the optimization process. Initially, the particles are located randomly. In this example a 3-dimensional space (rotation length, year and intensity of thinning) is used to facilitate the graphical representation of the process. Each particle has associated a value of the objective function (soil expectation value) that is calculated by simulating the forest growth in the process-based model. The best value called the **best global** ($\mathbf{x}^g$) is retained and all the particles will move towards that global best according to the rules of the SPO algorithm



An iteration of SPO begins with the production of two random numbers r_1 and r_2, which are uniformly distributed between 0 and 1. Then, particle positions are updated by adding velocities to the current values (element by element):

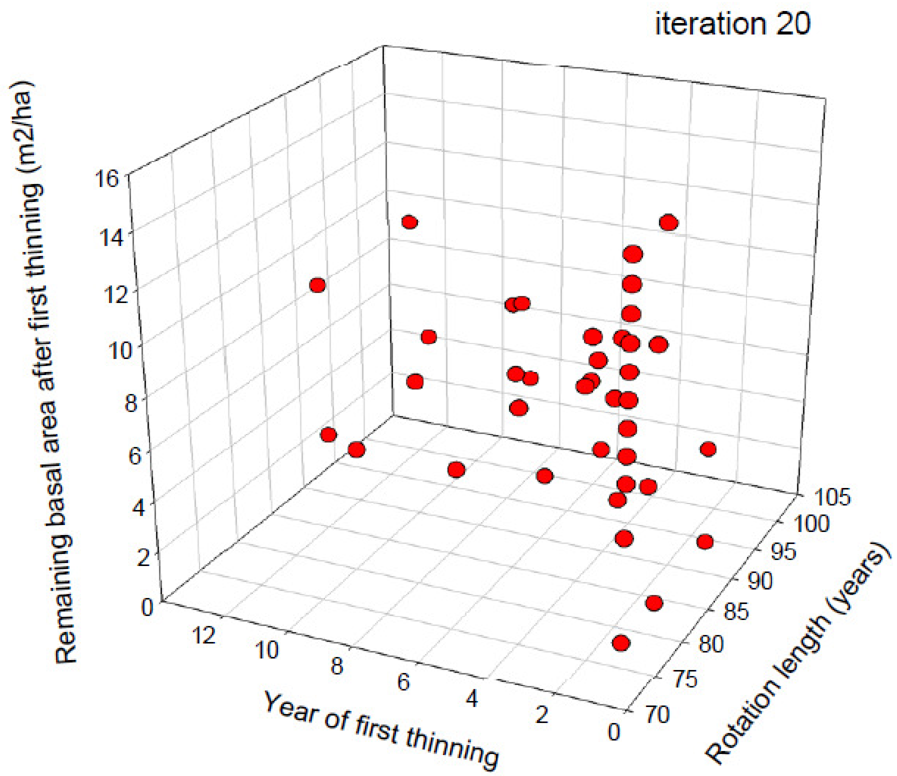
$\mathbf{x}_i^{updated} = \mathbf{x}_i + \mathbf{v}_i$

Velocities are up-dated as follows:

$\mathbf{v}_i^{updated} = w\mathbf{v}_i + c_1 r_1(\mathbf{x}_i^b - \mathbf{x}_i) + c_2 r_2(\mathbf{x}^g - \mathbf{x}_i)$

where w, c_1 and c_2 are parameters, $\mathbf{x}_i^b$ is the **i-particle best** and $\mathbf{x}^g$ is the **global best.**

Vector $\mathbf{v}_i$ determines the direction of movement for particle *i*. The above equation shows that the direction depends on both the particle best and the global best, i.e. a particle remembers its own best location, and also knows the location the best solution found by the whole swarm.


iteration 20
Remaining basal area after first thinning (m2/ha)
16
14
12
10
8
6
4
2
0
12
10
8
6
4
2
0
Year of first thinning
105
100
95
90
85
80
75
70
Rotation length (years)

N Boreal case (1a)

- AM in parenthesis when it will be considered automatically e.g. by natural regeneration and there is no real need to adapt. Often we have used BAUM/AM as many matters are kept same but only few things change.

Case study	Finland (UEF)	
Stand x site type	- Even-aged Scots pine pure stands - Soil type: less fertile site type (Vaccinium type or corresponding fertility of drained peatlands); Nutrients[11] (poor, average, high): average; Water[1] (low, average, high): average	
Management alternative	**No.: 1** **BAUM/AM:** BAUM/AM **System**: Even-aged. **Regeneration:** natural regeneration (A) or seeding (B) **Thinning type (below, above):** below **Thinning intensity (weak, average, heavy):** average (about 30-40% of basal area) **Entry interval:** twice over rotation, following thinning rules based on dominant height versus basal area development *) **Addressed climate change effect**: NPP **Adaptation strategy (B, RI, AC)**: B (RI, AC) **Expected level for addressed objectives (low, average, high)**: timber production (average), carbon sequestration (average), biodiversity (average)	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration or seeding	About 3000-5000 seedlings/ha within 5 years after regeneration, including also seedlings of Norway spruce and birch
Young	Tending	At mean height of 4-7 m tending to 2000-2500 seedlings/ha
Medium	Thinning 1	At dominant height of 11-15 m thinning to 900-1200 trees/ha
	Thinning 2	At dominant height of 18-20 m thinning to 400-500 trees/ha *) (AM: Finnish thinning rules will automatically adjust thinning timing to changes observed in growth).
Adult	Regeneration cut (if shelterwood system)	(A) If aiming for natural regeneration, then leaving about 50-150 seed trees/ha on site for about 5-10 years
	Final cut (if shelterwood system)	(A) About 5-10 years after regeneration cut removal of seed trees
	Clear cut.	(B) At mean DBH of 23-27 cm or at age of 90-110 yrs (after which it is used seeding if not applied natural regeneration based or use of seed trees)
Short description: The main objective is timber production, and thinning from below is applied for Scots pine regardless of thinning. Natural regeneration or seeding (with improved seed material) is used to increase the stand density in early phase of rotation targeting high stem wood quality in a cost-efficient way. It simultaneously increases also AC.		

[11] "Nutrients" refers to (content x availability); "Water" refers to (holding capacity x availability)

Case study	Finland	
Stand x site type	- Even-aged Scots pine pure stands - Soil type: medium fertile site type (Myrtillus type or corresponding fertility of drained peatlands); Nutrients(poor, average, high): average ; Water(low, average, high): average	
Management alternative	**No.: 2** **BAUM/AM:** BAUM (AM) **System**: Even-aged. **Regeneration:** planting **Thinning type (below, above):** below **Thinning intensity (weak, average, heavy):** average (about 30-40% of basal area) **Entry interval:** twice over rotation, following thinning rules based on dominant height versus basal area development *) **Addressed climate change effect**: NPP **Adaptation strategy (B, RI, AC)**: B (RI, AC) **Expected level for addressed objectives (low, average, high)**: timber production (high), carbon sequestration (high), biodiversity (average)	
Phase of development	**Process**	**Description**
Regeneration	Planting	About 2000 seedlings/ha (with age of 1-1.5 years), additional seeding naturally by Scots pine, Norway spruce and birch
Young	Tending	At mean height of 4-7 m tending to 1800-2000 seedlings/ha
Medium	Thinning 1	At dominant height of 13-15 m thinning to 900-1000 trees/ha
	Thinning 2	At dominant height of 18-20 m thinning to 400-500 trees/ha *) (AM: Finnish thinning rules will automatically adjust thinning timing to changes observed in growth).
Adult	Clear cut..	at mean DBH of 24-28 cm or at age of 80-100 yrs
Short description: The main objective is timber production, and thinning from below is applied for Scots pine regardless of thinning. In addition to planting (with improved material), natural seeding increases the stand density in early phase of rotation, which is needed for high stem wood quality on medium fertile site. This increases also AC simultaneously.		

Case study	Finland	
Stand x site type	- Even-aged Norway spruce pure stands - Soil type: Medium fertile site type (Myrtillus type or corresponding fertility of drained peatlands); Nutrients (poor, average, high): average ; Water(low, average, high): average	
Management alternative	**No.: 3** **BAUM/AM:** BAUM/AM **System**: Even-aged. **Regeneration:** planting **Thinning type (below, above):** below (above) **Thinning intensity (weak, average, heavy):** average (about 30-40% of basal area) **Entry interval:** twice over rotation, following thinning rules based on dominant height versus basal area development *) **Addressed climate change effect**: NP, drought (sandy soils with lower water holding capacity) **Adaptation strategy (B, RI, AC)**: B, RI, AC **Expected level for addressed objectives (low, average, high)**: timber production (average), carbon sequestration (average), biodiversity (average)	
Phase of development	**Process**	**Description**
Regeneration	Planting	BAUM: About 1600-1800 Norway spruce seedlings/ha (with age of 1-1.5 years), additional seeding naturally; AM: planting of Norway spruce of more southern genotype (drought resistant) or Scots pine on medium fertile sites with lower soil water holding capacity.
Young	Tending	At mean height of 3-4 m tending to 1600-1800 Norway spruce seedlings/ha (or 2000 Scots pine seedlings/ha)
Medium	Thinning 1	At dominant height of 12-16 m thinning to 900-1000 trees/ha in Norway spruce (see Management alternative 2 for Scots pine)
	Thinning 2	At dominant height of 18-20 m thinning to 400-500 trees/ha *) AM: Finnish thinning rules will automatically adjust thinning timing to changes observed in growth.
Adult	Clear cut..	BAUM: at mean DBH of 25-28 cm or at age of 80-100 yrs in Norway spruce; AM: possibly shorter rotation length needed in Norway spruce especially if not more southern (drought resistant) genotype used (see Management alternative 2 for Scots pine)
Short description: The main objective is timber production, and thinning from below is applied for Norway spruce in first thinning, in latter thinning also thinning from above may be applied as well (see Management alternative 2 for Scots pine). RI, AC: use of more southern (drought resistant) genotypes of Norway spruce on soils with lower water holding capacity or use of local Scots pine.		

Case study	Finland	
Stand x site type	- Even-aged Norway spruce pure stands - Soil type: Fertile site type (Oxalis-Myrtillus type or corresponding fertility of drained peatlands); Nutrients(poor, average, high): high ; Water(low, average, high): high	
Management alternative	**No.:4** **BAUM/AM:** BAUM (AM) **System**: Even-aged. **Regeneration:** planting **Thinning type (below, above):** below (above) **Thinning intensity (weak, average, heavy):** average (about 30-40% of basal area) **Entry interval:** twice over rotation, following thinning rules based on dominant height versus basal area development **Addressed climate change effect**: NPP **Adaptation strategy (B, RI, AC)**: B **Expected level for addressed objectives (low, average, high)**: timber production (high), carbon sequestration (high), biodiversity (high)	
Phase of development	**Process**	**Description**
Regeneration	Planting	About 1600-1800 seedlings/ha (with age of 1-1.5 years), additional seeding naturally
Young	Tending	At mean height of 3-4 m tending to 1600-1800 seedlings/ha
Medium	Thinning 1	At dominant height of 12-16 m thinning to 900-1000 trees/ha
	Thinning 2	At dominant height of 18-20 m thinning to 400-500 trees/ha. (AM: Finnish thinning rules will automatically adjust thinning timing to changes observed in growth).
Adult	Clear cut..	at mean DBH of 26-30 cm or at age of 70-90 yrs
Short description: The main objective is timber production, and thinning from below is applied for Norway spruce in first thinning, in latter thinning also thinning from above may be applied as well.		

Case study	Finland	
Stand x site type	- Even-aged birch (Silver birch, Betula pendula) pure stands on mineral soils or (Downy birch, Betula pubescens) on drained peatlands - Soil type: Medium to fertile site types (Myrtillus or Oxalis-Myrtillus type or corresponding fertility of drained peatlands); Nutrients(poor, average, high): medium to high ; Water(low, average, high): medium to high	
Management alternative	**No.: 5** **BAUM/AM:** BAUM **System**: Even-aged. **Regeneration:** planting **Thinning type (below, above):** below **Thinning intensity (weak, average, heavy):** average (about 30-40% of basal area) **Entry interval: once or** twice over rotation, following thinning rules based on dominant height versus basal area development *) **Addressed climate change effect**: NPP **Adaptation strategy (B, RI, AC)**: B **Expected level for addressed objectives (low, average, high)**: timber production (medium to high), carbon sequestration (medium), biodiversity (high)	
Phase of development	**Process**	**Description**
Regeneration	Planting	About 1600-2000 seedlings/ha (with age of 1-1.5 years), additional seeding naturally
Young	Tending	At mean height of 4-7 m tending to 1600 seedlings/ha
Medium	Thinning 1	At dominant height of 14-16 m thinning to 700-800 trees/ha
	Thinning 2	At dominant height of 18-20 m thinning to 400-500 trees/ha, if needed *)
Adult	Regeneration cut (if shelterwood system)	-
	Final cut (if shelterwood system)	-
	Clear cut..	at mean DBH of 26-30 cm for Silver birch and 22-25 cm for Downy birch or at age of 60-70 yrs
Short description: The main objective is timber production, and thinning from below is applied for birch in thinning. Birch is a winner under changing climate because of its high adaptive capacity (high regeneration success and growth)		

Mediterranean Portugal case (4b)

EU Motive Project

Portuguese contribution for deliverable 4.3

Margarida Tomé, Jordi Garcia-Gonzalo, João Palma, Jose Guilherme Borges

Forest Research Centre, School of Agriculture, Technical University of Lisbon

Content:

A - Methodology for creating Alternative Managements

This deliverable suggests that "best" AM are proposed *a priori* for a certain scenario either to utilize the potential benefits arising from a changing climate (scenario B), reduce potential negative impacts arising from a changing climate (scenario RI) or increase adaptive capacity to prepare for uncertain future climate (AC).

The methodology being developed in Portugal does not fit under the *a priori* definitions that underlie this deliverable. Methods and tools will be developed to 1) generate the decision space (feasible set of AM), 2) compare AM according to a set of decision-maker goals and 3) select the "best" AM or the "best" combination of AM in the case of stand and landscape-level problems, respectively, under each scenario (Figure 1). The selection (or creation) of AM is thus made *a posteriori* in the sense that it is based on a comparison between AM rather than on an early ad-hoc screening that does not take into account **case-specific** stakeholders' preferences and AM interactions. The generation of the decision space will take advantage of process-based models (if climate change is considered) or empirical models (if climate change scenarios are not considered) to project conditions and outcomes of interest associated to each stand-level AM. This is instrumental to generate both the resource capability and the policy models. Both mathematical programming techniques (e.g. stochastic dynamic programming, mixed integer programming, goal programming) and heuristics (e.g. population-based methods) are then used to compare AM or AM combinations to select the "best" one if stakeholders' preferences are assumed to be known. Else mathematical programming is combined with Pareto frontier methods to retrieve the "best" AM or combination of AM under each scenario.

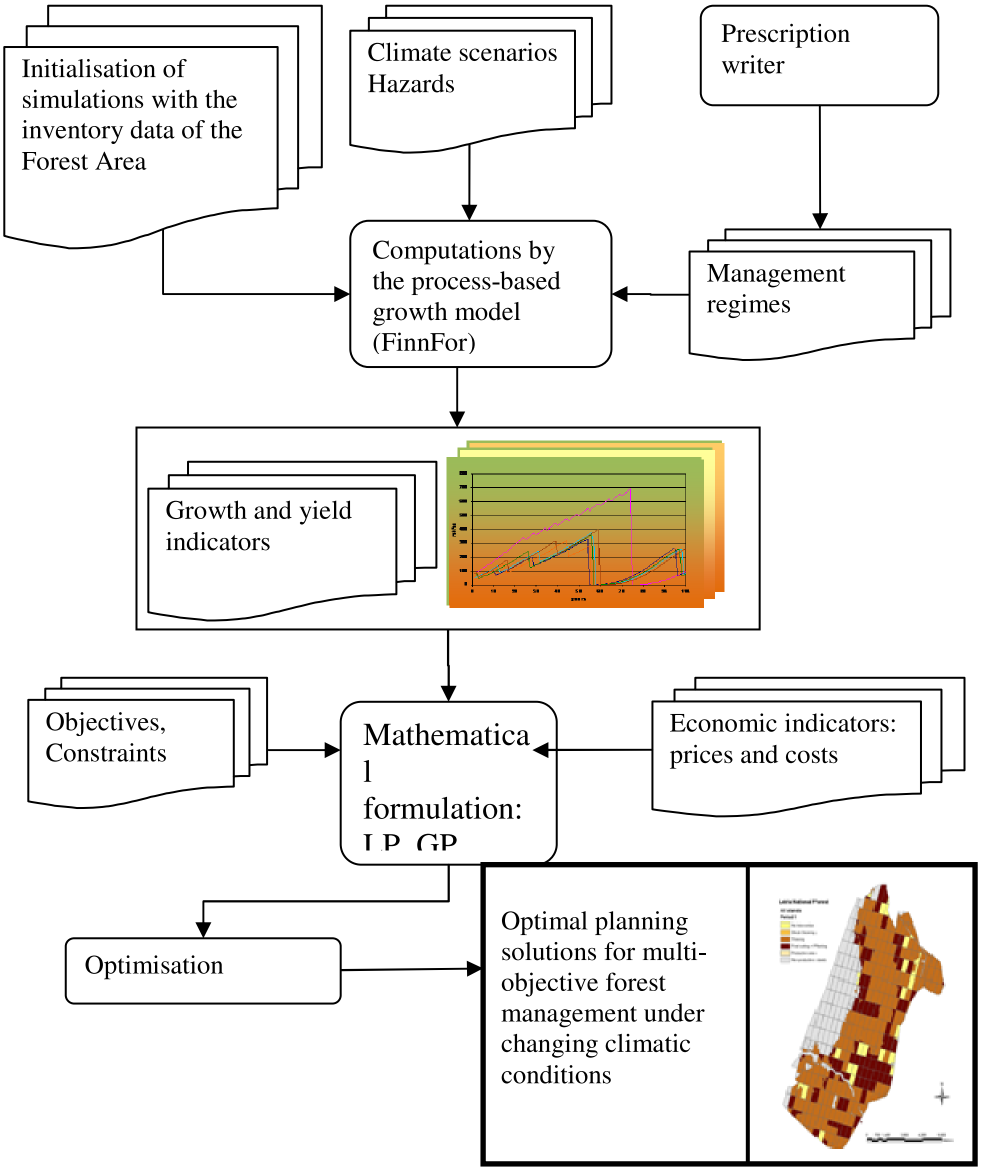


Figure 1. Scheme of the methodology followed for adaptive forest management at landscape/forest/regional level.

B – Business As Usual Managements (BAUM)

There are three forest species in our case studies: *Pinus pinaster*, *Quercus suber* and *Eucalyptus globulus*.

The current BAUMs of these stands are the following:

Pinus pinaster:

- Stand type: Even-aged on sandy soils (paleodunes)
- Cutting cycle: varies between 50 and 80
- Regeneration: Natural
- Thinning: First thinning is usually performed at year 20, then thinnings are performed until 5 years before harvest. Usually 5 to 6 thinnings are performed during the rotation.
- Current Objective: Constant Volume and volume per diameter class

Quercus suber :

- Stand type: Even-aged or uneven-aged on medium-heavy texture soils
- Cutting cycle: trees are not clearcut. Cork extraction is the main product. Tree life cycle estimated at 120 years
- Regeneration: recently planted (last 20 years with approx 300-400 trees ha^{-1}) or natural regeneration
- Thinning: The current goal is a density of approx 50% of tree cover (final density between 40-60 trees/ha) under a silvoarable or silvopastural system, or higher densities under forestry systems
- Current Objective: After the first debarking that occurs when the stand attains an average dbh (over bark) around 22 cm, the cork is extracted in a 8-10 years cycle up to an height that depends on the type of cork and tree diameter (2*perimeter for virgin cork, 2.5*perimeter for second cork and 3*perimeter for mature cork). In the branches cork can be extracted until the branch presents a perimeter equal to 70 cm.

Eucalyptus globulus:

- Stand type: Even-aged on medium-heavy texture soils
- Cutting cycle: varies between 9 and 13
- Regeneration: Planted. Density is around 1100-1500. If stands are coppiced, stool thinning is performed usually in year 3 and 1 to 3 sprouts per stump are selected.
- Thinning: There is no thinning in Eucalyptus stands.
- Current Objective: Wood fiber for pulp industry.

S Boreal case (1b)

Description:

For the Kronoberg case study, we plan to use the FTM model to project the state of the forest within a landscape until 2100 under the A1B scenario and under no climate change. We use BAUM and a wind damage risk adapted management regime (AM). **Part of the AM depends on location**. These simulations will be made at a time step of 5 yrs. The WINDA-GALES model calculates the annual probability of wind damage for a specific state of the forest. To calculate the probability of wind damage we need to use climate data for a 30 yrs time period. We run the WINDA-GALES model on states of the forest for specific years and for a relevant 30 yr wind climate. The model is spatially explicit.For no climate change effect we plan to calculate the probability of wind damage for individual years and aggregate these cover 30 yr periods centered on years 2015, 2030 and 2085 using wind data for the reference period using BAUM and AM separately.For the A1B scenario we plan to make the corresponding calculations using BAUM and AM separately. A1B will affect the growth of the forest starting in year 2001. In the case of AM, this will be applied starting in year 2001 in one simulation and in year 2031 in a second simulation (BAUM until 2030).

This case study is specifically addressed at the spatial level. The AMs will depend on the stands location and therefore the proposed approach for defining BAUM and AM regimes does not apply here. At the moment the AM management strategy for current climate has been devised with the assistance of the Kronoberg stakeholder panel.

The submitted BAUMs and AMs depict what happens if they are applied without climate change. The growth engine in our model (FTM) accounts for climate change by adjusting site index. This means that the management rules applied will automatically change under climate change since they in most cases are a function of site index. In the simulations the following treatments are functions of the SI:

- Regeneration: Number of seedlings planted and naturally regenerated
- Tending: Number of seedlings after treatment
- Thinning: timing of treatment (site index in combination with Hdom and basal area)
- Final/regeneration felling: timing of treatment

Case study	Kronoberg	
Stand x site type	- Even-aged spruce pure stands - Soil type: podzol ; Nutrients: average ; Water: average	
Management alternative	**No.:** 1 **BAUM/AM:** BAUM **System**: Even-aged **Regeneration:** Planting **Thinning type (below, above):** below **Thinning intensity (weak, average, heavy):** average, see below **Entry interval:**see below **Addressed climate change effect**: N/A **Adaptation strategy (B, RI, AC)**: N/A **Expected level for addressed objectives (low, average, high)**:	
Phase of development	**Process**	**Description**
Regeneration	Planting	2700 spruce seedlings per hectare
Young	Tending	At age of 10 years to 2500 stems/ha 90% spruce and 10% birch
Medium	Thinning 1	H_{dom} 11 m, Basal area 25 m^2, D 12 cm, (Age 31 years) Removed 35% of basal area and 40% of stems
	Thinning 2	H_{dom} 15 m, Basal area 29 m^2, D 17 cm, (Age 41 years) Removed 30% of basal area and 32% of stems
	Thinning 3	H_{dom} 19 m, Basal area 34 m^2, D 23 cm, (Age 56 years) Removed 30% of basal area and 32% of stems
	Thinning 4	H_{dom} 19 m, Basal area 36 m^2, D 30 cm, (Age 76 years) Removed 30% of basal area and 32% of stems
Adult	Regeneration cut (if shelterwood system)	
	Final cut (if shelterwood system)	
	Clear cut..	At 91 years, H_{dom}27 m, D 36, Basal area 35 m^2
Short description: BAUM management schedule for a pure and even-aged spruce stand of average to good productivity in southern Sweden The main objective is timber production.		

Case study	Kronoberg	
Stand x site type	- Even-aged mixed coniferous stands - Soil type: podzol ; Nutrients: average ; Water: average	
Management alternative	**No.: 1** **BAUM/AM:** BAUM **System**: Even-aged.. **Regeneration:** Planting + Natural regeneration **Thinning type (below, above):** below **Thinning intensity (weak, average, heavy):** average, see below **Entry interval:**see below **Addressed climate change effect**: N/A **Adaptation strategy (B, RI, AC)**: N/A **Expected level for addressed objectives (low, average, high)**:	
Phase of development	**Process**	**Description**
Regeneration	Planting + Natural regeneration	Planting of 1400 spruce seedlings per hectare plus natural regeneration of mainly pine and birch 10000-15000 seedlings/ha
Young	Tending	At age of 10 years to 2700 stems/ha 45% pine, 45% spruce and 10% birch
Medium	Thinning 1	H_{dom} 12 m, Basal area 25 m^2, D 12 cm, (Age 30 years) Removed 32% of basal area and 37% of stems
	Thinning 2	H_{dom} 16 m, Basal area 30 m^2, D 17 cm, (Age 40 years) Removed 27% of basal area and 29% of stems
	Thinning 3	H_{dom} 19 m, Basal area 34 m^2, D 21 cm, (Age 50 years) Removed 27% of basal area and 29% of stems
	Thinning 4	H_{dom} 23 m, Basal area 36 m^2, D 23 cm, (Age 76 years) Removed 27% of basal area and 29% of stems
Adult	Regeneration cut (if shelterwood system)	H_{dom} 27 m, Basal area 37 m^2, D 35 cm, (Age 90 years) Leaving 10 m^2 basal area in shelter layer of mainly pine
	Final cut (if shelterwood system)	Final cut of shelter after 5 years (age 95)
	Clear cut..	
Short description: BAUM management schedule for a mixed coniferous and even-aged stand of average to goodproductivity in southern Sweden The main objective is timber production.		

Case Study	Kronoberg	
Stand x site type	- Even-aged mixed stands - Soil type: podzol ; Nutrients: average ; Water: average	
Management alternative	**No.: 1** **BAUM/AM:** BAUM **System**: Even-aged.. **Regeneration:** Natural regeneration **Thinning type (below, above):** below **Thinning intensity (weak, average, heavy):** average, see below **Entry interval:**see below **Addressed climate change effect**: N/A **Adaptation strategy (B, RI, AC)**: N/A **Expected level for addressed objectives (low, average, high)**:	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	10000-15000 seedlings/ha
Young	Tending	At age of 10 years to 3000 stems/ha of all species (pine, spruce, birch, oak and other broadleaves At age of 15 years to 2000 stems/ha
Medium	Thinning 1	H_{dom} 12 m, Basal area 22 m^2, D 11 cm, (Age 30 years) Removed 25% of basal area and 30% of stems
	Thinning 2	H_{dom} 16 m, Basal area 22 m^2, D 16 cm, (Age 40 years) Removed 20% of basal area and 23% of stems
	Thinning 3	H_{dom} 20 m, Basal area 25 m^2, D 20 cm, (Age 50 years) Removed 20% of basal area and 23% of stems
	Thinning 4	H_{dom} 22 m, Basal area 25 m^2, D 25 cm, (Age 60 years) Removed 20% of basal area and 23% of stems
	Thinning 5	H_{dom} 25 m, Basal area 25 m^2, D 30 cm, (Age 80 years) Removed 20% of basal area and 23% of stems
Adult	Regeneration cut (if shelterwood system)	H_{dom} 26 m, Basal area 27 m^2, D 33 cm, (Age 90 years) Leaving 10 m^2 basal area in shelter layer of all species except spruce
	Final cut (if shelterwood system)	Shelter removed in two steps after 5 and 10 yeas
	Clear cut..	
Short description: BAUM management schedule for a mixed and even-aged stand of average to goodproductivity in southern Sweden The main objective is timber production and nature conservation		

Case Study	Kronoberg	
Stand x site type	- Even-aged pure spruce stand - Soil type: podzol ; Nutrients: average ; Water: average	
Management alternative	**No.:** 1 **BAUM/AM:** AM **System**: Even-aged.. **Regeneration:** Planting **Thinning type (below, above):** below **Thinning intensity (weak, average, heavy):** average, see below **Entry interval:**see below **Addressed climate change effect**: Increasing risk of wind damage **Adaptation strategy (B, RI, AC)**:RI **Expected level for addressed objectives (low, average, high)**:	
Phase of development	**Process**	**Description**
Regeneration	Planting	2700 spruce seedlings per hectare
Young	Tending	At age of 10 years to 2500 stems/ha 90% spruce and 10% birch
Medium	Thinning 1	H_{dom} 11 m, Basal area 25 m^2, D 12 cm, (Age 31 years) Removed 35% of basal area and 40% of stems
	Thinning 2	H_{dom} 15 m, Basal area 29 m^2, D 17 cm, (Age 41 years) Removed 30% of basal area and 32% of stems
	Thinning 3	H_{dom} 19 m, Basal area 34 m^2, D 23 cm, (Age 56 years) Removed 30% of basal area and 32% of stems
Adult	Regeneration cut (if shelterwood system)	
	Final cut (if shelterwood system)	
	Clear cut..	At 76 years, H_{dom} 24 m, D 30, Basal area 35 m^2
Short description: AM management schedule for a pure and even-aged spruce stand of average to good productivity in southern Sweden The main objective is timber production. Rotation period is shortened and last thinning carried out before a H_{dom} of 21 m to reduce the risk of wind damage		

Case Study	Kronoberg	
Stand x site type	- Even-aged mixed coniferous stands - Soil type: podzol ; Nutrients: average ; Water: average	
Management alternative	**No.: 1** **BAUM/AM:** AM **System**: Even-aged.. **Regeneration:** Planting + Natural regeneration **Thinning type (below, above):** below **Thinning intensity (weak, average, heavy):** average, see below **Entry interval:**see below **Addressed climate change effect**: Increasing risk of wind damage **Adaptation strategy (B, RI, AC)**: RI **Expected level for addressed objectives (low, average, high)**:	
Phase of development	**Process**	**Description**
Regeneration	Planting + Natural regeneration	Planting of 1400 spruce seedlings per hectare plus natural regeneration of mainly pine and birch 10000-15000 seedlings/ha
Young	Tending	At age of 10 years to 2700 stems/ha 45% pine, 45% spruce and 10% birch
Medium	Thinning 1	H_{dom} 12 m, Basal area 25 m^2, D 12 cm, (Age 30 years) Removed 32% of basal area and 37% of stems
	Thinning 2	H_{dom} 16 m, Basal area 30 m^2, D 17 cm, (Age 40 years) Removed 27% of basal area and 29% of stems
	Thinning 3	H_{dom} 19 m, Basal area 34 m^2, D 21 cm, (Age 50 years) Removed 27% of basal area and 29% of stems
Adult	Regeneration cut (if shelterwood system)	H_{dom} 25 m, Basal area 40 m^2, D 30 cm, (Age 75 years) Leaving 10 m^2 basal area in shelter layer of mainly pine
	Final cut (if shelterwood system)	Final cut of shelter after 5 years (age 80)
	Clear cut..	
Short description: AM management schedule for a mixed coniferous and even-aged stand of average to goodproductivity in southern Sweden The main objective is timber production. Rotation period is shortened and last thinning carried out before a H_{dom} of 21 m to reduce the risk of wind damage		

Case Study	Kronoberg	
Stand x site type	- Even-aged mixed stands - Soil type: podzol; Nutrients: average ; Water: average	
Management alternative	**No.: 1** **BAUM/AM:** AM **System**: Even-aged.. **Regeneration:** Natural regeneration **Thinning type (below, above):** below **Thinning intensity (weak, average, heavy):** average, see below **Entry interval:**see below **Addressed climate change effect**: Increasing risk of wind damage **Adaptation strategy (B, RI, AC)**: RI **Expected level for addressed objectives (low, average, high)**:	
Phase of development	**Process**	**Description**
Regeneration	Natural regeneration	10000-15000 seedlings/ha
Young	Tending	At age of 10 years to 3000 stems/ha of all species (pine, spruce, birch, oak and other broadleaves At age of 15 years to 2000 stems/ha
Medium	Thinning 1	H_{dom} 12 m, Basal area 22 m^2, D 11 cm, (Age 30 years) Removed 25% of basal area and 30% of stems
	Thinning 2	H_{dom} 16 m, Basal area 22 m^2, D 16 cm, (Age 40 years) Removed 20% of basal area and 23% of stems
	Thinning 3	H_{dom} 20 m, Basal area 25 m^2, D 20 cm, (Age 50 years) Removed 20% of basal area and 23% of stems
Adult	Regeneration cut (if shelterwood system)	H_{dom} 24 m, Basal area 23 m^2, D 28 cm, (Age 90 years) Leaving 10 m^2 basal area in shelter layer of all species except spruce
	Final cut (if shelterwood system)	Shelter removed in two steps after 5 and 10 yeas
	Clear cut..	
Short description: AM management schedule for a mixed and even-aged stand of average to goodproductivity in southern Sweden The main objective is timber production and nature conservation. Rotation period is shortened and last thinning carried out before a H_{dom} of 21 m to reduce the risk of wind damage		

Case Study	Kronoberg	
Stand x site type	- Even-aged pure birch stand - Soil type: podzol ; Nutrients: average ; Water: average	
Management alternative	**No.: 1** **BAUM/AM:** AM **System**: Even-aged.. **Regeneration:** Planting **Thinning type (below, above):** below **Thinning intensity (weak, average, heavy):** average, see below **Entry interval:**see below **Addressed climate change effect**:Increasing risk of wind damage **Adaptation strategy (B, RI, AC)**:RI **Expected level for addressed objectives (low, average, high)**:	
Phase of development	**Process**	**Description**
Regeneration	Planting	3500 spruce seedlings per hectare
Young	Tending	At age of 10 years to 2400 stems/ha
Medium	Thinning 1	H_{dom} 12 m, Basal area 25 m^2, D 12 cm, (Age 21 years) Removed 30% of basal area and 35% of stems
	Thinning 2	H_{dom} 15 m, Basal area 29 m^2, D 17 cm, (Age 36 years) Removed 25% of basal area and 30% of stems
	Thinning 3	H_{dom} 19 m, Basal area 34 m^2, D 23 cm, (Age 36 years) Removed 25% of basal area and 30% of stems
Adult	Regeneration cut (if shelterwood system)	H_{dom} 26 m, Basal area 30 m^2, D 29 cm, (Age 66 years) Leaving 5 m^2 basal area of birch as seed trees
	Final cut (if shelterwood system)	Seed trees removed after 5 years
	Clear cut..	
Short description: AM management schedule for a pure and even-aged birch stand of average to goodproductivity in southern Sweden The main objective is timber production. Rotation period is shortened and last thinning carried out before a H_{dom} of 21 m to reduce the risk of wind damage. Applied on site topographically exposed to wind damage and dominated by spruce or mixed conifers		

Atlantic Wales case (2a)

Description: BAUM regimes represent current Forest Management Alternatives (FMAs) appropriate to the Clocaenog and Gwydr forest areas in the WALES case study. AM will be based around changes in proportion and structure of FMAs as well as diversification of species that are achievable, which would be expected to improve resilience to climate change, and are compatible with current policy for forest climate change adaptation. Current FMAs and species will be mapped spatially at the sub-compartment (i.e. forest stand) level, and potential AM alternatives will be selected for each using the 'MOTIVE8-Wales' suite of models. Species suitability and potential yield in future climate scenarios will be examined for each sub-compartment, and decision trees for conversion of FMAs using soil and climate data will be applied. The choice of thinning regime, stand rotation or transformation to CCF will be assessed and constrained in relation to wind risk. The range of potential regimes (FMA / species choice) and their respective impact on social, economic and environmental sustainability indicators will be used as the basis for AM decisions by different MOTIVE manager types. The BAUM regimes are provided below.

- The Sitka figures assume 2500 trees planted per ha. So for FMA 2 where there is only 40% planting that's 40% of 2500. The Birch figures assume 1900 trees planted per ha (bare root). So for again for FMA 2 that's 40% of 1900.

Stand 1 site type 1: Unmanaged Nature Reserve (FMA 1): Oak

Case study	Wales	
Stand 1 site type	- Unmanaged Nature Reserve: Oak - Soil type: xxx ; Nutrients[12] (poor, average, high): xxx ; Water[1](low, average, high): xxx	
Management alternative	**No.: 1** **BAUM/AM: BAUM** **System**: - Unmanaged Nature Reserve: Oak; mixed age and stand structure **Regeneration: Yes, 100%** **Thinning type (below, above): N/A** **Thinning intensity (weak, average, heavy): N/A** **Entry interval:**N/A **Addressed climate change effect**: N/A **Adaptation strategy (B, RI, AC)**: N/A **Expected level for addressed objectives (low, average, high)**: Carbon sequestration (high), Biodiversity (high), Recreation (medium)	
Phase of development	**Process**	**Description**
Regeneration	Natural Regeneration	X trees/ha, H_{dom} = X m (dominant height) at X years
Young	Tending	N/A
Medium	Thinning 1	N/A
	Thinning 2	N/A
	……	
Adult	Regeneration cut (if shelterwood system)	N/A
	Final cut (if shelterwood system)	N/A
	Clear cut..	N/A
Short description: The main aim of management in these stands is to provide 'reference stands' where the impact of ecological processes in forests can be followed without disruption from timber management. The categories that are covered within this FMA are generally known in British forestry as 'minimum intervention' and/or 'natural reserves'.		

[12]"Nutrients" refers to (content x availability); "Water" refers to (holding capacity x availability)

Stand 2 site type 1: Transformation to CCF (FMA 2): Sitka spruce YC 14 (soil type: xx, nutrients: xx, water: xx)

Case study	Wales	
Stand 2 site type	- Continuous Cover Forestry (CCF): Sitka spruce YC 14 - Soil type: xxx ; Nutrients (poor, average, high): xxx ; Water(low, average, high): xxx	
Management alternative	**No.: 2** **BAUM/AM: BAUM** **System**: - Transformation to CCF (FMA 2): Sitka spruce; mixed age and stand structure **Regeneration: Yes, 60%** **Thinning type (below, above):** above? **Thinning intensity (weak, average, heavy): heavy** **Entry interval: 10y** **Addressed climate change effect**: N/A **Adaptation strategy (B, RI, AC)**: N/A **Expected level for addressed objectives (low, average, high)**: Carbon sequestration (high), Biodiversity (high), Recreation (medium), timber production (medium)	
Phase of development	**Process**	**Description**
Regeneration	Natural Regeneration (60%)	X trees/ha, H_{dom} = X m (dominant height) at X years
	Planting (40%)	1000 trees/ha, H_{dom} = X m (dominant height) at X years
Young	Intermediate Thinning	Year 20; D_{dom} = 12cm; thinning to X stem/ha
Medium	Crown Thinning 1	Year 30; D_{dom} = 17cm; thinning to X stem/ha
	Crown Thinning 2	Year 40; D_{dom} = 22cm; thinning to X stem/ha
	Gap Thinning	Year 50; D_{dom} = 28cm; thinning to X stem/ha
Adult	Frame Tree Thinning	Year 60; D_{dom} = 32cm; thinning to X stem/ha
	Partial Clearfell	Year 80; D_{dom} = 38cm; thinning to X stem/ha
Short description: The practice of CCF generally occurs on sites of high visual, recreational or biodiversity value where it is considered that clear felling, even in small coupes (0.25-1.0 ha), is not compatible with delivering other non-market benefits from the forest. Under such circumstances, and on windfirm sites, a range of lower impact silvicultural systems can be used to implement CCF and provide a sustained supply of timber and other ecosystem products.		

Stand 2 site type 2: Transformation to CCF (FMA 2): Birch YC 4 (soil type: xx, nutrients: xx, water: xx)

Case study	Wales	
Stand 2 site type	- Continuous Cover Forestry (CCF): Birch YC 4 - Soil type: xxx ; Nutrients (poor, average, high): xxx ; Water(low, average, high): xxx	
Management alternative	**No.: 2** **BAUM/AM: BAUM** **System**: - Transformation to CCF (FMA 2): Birch; mixed age and stand structure **Regeneration: Yes, 60%** **Thinning type (below, above):** above? **Thinning intensity (weak, average, heavy): heavy** **Entry interval: 10y** **Addressed climate change effect**: N/A **Adaptation strategy (B, RI, AC)**: N/A **Expected level for addressed objectives (low, average, high)**: Carbon sequestration (high), Biodiversity (high), Recreation (medium), timber production (low)	
Phase of development	**Process**	**Description**
Regeneration	Natural Regeneration (60%)	X trees/ha, H_{dom} = X m (dominant height) at X years
	Planting (40%)	760 trees/ha, H_{dom} = X m (dominant height) at X years
Young	Intermediate Thinning	Year 20; D_{dom} = 7cm; thinning to X stem/ha
Medium	Crown Thinning 1	Year 30; D_{dom} = 10cm; thinning to X stem/ha
	Crown Thinning 2	Year 40; D_{dom} = 12cm; thinning to X stem/ha
	Gap Thinning	Year 50; D_{dom} = 18cm; thinning to X stem/ha
Adult	Frame Tree Thinning	Year 60; D_{dom} = 22cm; thinning to X stem/ha
	Partial Clearfell	Year 80; D_{dom} = 30cm; thinning to X stem/ha
Short description: The practice of CCF generally occurs on sites of high visual, recreational or biodiversity value where it is considered that clear felling, even in small coupes (0.25-1.0 ha), is not compatible with delivering other non-market benefits from the forest. Under such circumstances, and on windfirm sites, a range of lower impact silvicultural systems can be used to implement CCF and provide a sustained supply of timber and other ecosystem products.		

Stand 4 site type 1: Intensive even-aged management (FMA 4): Sitka spruce YC 14 (soil type: xx, nutrients: xx, water: xx)

Case study	Wales	
Stand 4 site type	- Intensive even-aged management : Sitka spruce YC 14 - Soil type: xxx ; Nutrients (poor, average, high): xxx ; Water(low, average, high): xxx	
Management alternative	**No.: 4** **BAUM/AM: BAUM** **System**: - Intensive even-aged management: Sitka spruce YC 14: even age and stand structure **Regeneration: No** **Thinning type (below, above):** above? **Thinning intensity (weak, average, heavy): average** **Entry interval: 10-15y** **Addressed climate change effect**: N/A **Adaptation strategy (B, RI, AC)**: N/A **Expected level for addressed objectives (low, average, high)**: Carbon sequestration (low), Recreation (low), timber production (high)	
Phase of development	**Process**	**Description**
Regeneration	Natural Regeneration	N/A
Young	Intermediate Thinning 1	Year 25; D_{dom} = 13cm; thinning to X stem/ha
Medium	Intermediate Thinning 2	Year 35; D_{dom} = 20cm; thinning to X stem/ha
	Clearfell	Year 50; D_{dom} = 30cm; thinning to X stem/ha
Adult	N/A	
Short description: The main aim of management is produce sawlogs for the construction market using even-aged management regimes. Management has to take into consideration other forest functions identified through the forest design process and species choice has to conform to the guidance laid down by the UKWAS standard – see introductory remarks. Thus Sitka spruce is unlikely to exceed 65 per cent of a stand, even where it is the most productive species.		

Stand 4 site type 2: Intensive even-aged management (FMA 4): Douglas fir (soil type: xx, nutrients: xx, water: xx)

Case study	Wales	
Stand 4 site type	- Intensive even-aged management (FMA 4): Douglas fir - Soil type: xxx ; Nutrients (poor, average, high): xxx ; Water(low, average, high): xxx	
Management alternative	**No.: 4** **BAUM/AM: BAUM** **System**: - Intensive even-aged management (FMA 4): Douglas fir; even age and stand structure **Regeneration: No** **Thinning type (below, above):** above? **Thinning intensity (weak, average, heavy): average** **Entry interval: 10-25y** **Addressed climate change effect**: N/A **Adaptation strategy (B, RI, AC)**: N/A **Expected level for addressed objectives (low, average, high)**: Carbon sequestration (medium), Recreation (low), timber production (medium)	
Phase of development	**Process**	**Description**
Regeneration	Natural Regeneration	N/A
Young	Intermediate Thinning 1	Year 25; D_{dom} = 13cm; thinning to X stem/ha
Medium	Intermediate Thinning 2	Year 35; D_{dom} = 17cm; thinning to X stem/ha
Adult	Clearfell	Year 60; D_{dom} = 31cm; thinning to X stem/ha
Short description: The main aim of management is produce sawlogs for the construction market using even-aged management regimes. Management has to take into consideration other forest functions identified through the forest design process and species choice has to conform to the guidance laid down by the UKWAS standard – see introductory remarks. Thus Sitka spruce is unlikely to exceed 65 per cent of a stand, even where it is the most productive species.		