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Models and linker functions (indicators) for ecosystem services

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Abstract:

In this document, we present the linker functions that will be implemented by forest growth models in order to assess ecosystem services related to wood production, carbon storage, biodiversity preservation and protection against natural hazards. Suggestions are also made for wood energy biomass and game hunting, two ecosystem services that will be considered in some specific case study areas of the ARANGE project. For each linker function, we provide its definition, justification and the equations and algorithms for its operational implementation. We also provide perspectives how to adapt the linker functions at the landscape scale and to permit cross case studies comparisons.

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1 Wood Production

Wood production represents a major ecosystem service provided by forests. It will be represented by **three main metrics: volume of timber harvested, forest productivity and forest stocking**. Each of these metrics will be reported on a **volumetric basis** such that timber harvested will be measured in units of $m^3ha^{-1}yr^{-1}$, while productivity and forest stocking will be measured in $m^3ha^{-1}yr^{-1}$ and m^3ha^{-1}, respectively. Of the nine forests models being used in ARANGE, seven models provide forest development on a volumetric basis directly. The models that do not natively simulate stand state on a volumetric basis will convert their output into forest volume such that direct comparisons across model outputs and across case studies can be made. For models that simulate other units, conversions to m^3ha^{-1} will be done using algorithms that are internally consistent with the simulated growth and allometric relationships that the model is based on.

For all wood production metrics, **5 cm DBH classes are used** to aggregate the data. **By default, the minimum diameter is 5 cm** (e.g. diameter class 1: 5 < DBH ≤ 10 cm; class 2: 10 < DBH ≤ 15 cm, etc.). The volume considered is **total bole volume over bark** (without leaves and branches).

1.1 Timber volume harvested

1.1.1 Definition

Total annual volume of timber harvested from a stand ($\boldsymbol{TVH_{total}}$). This base metric aggregates the volume of timber harvested across all tree species and all diameter classes.

1.1.2 Description

Units: $m^3ha^{-1}yr^{-1}$.

If a model does not calculate timber production in $m^3ha^{-1}yr^{-1}$, a conversion to this unit, using equations that are internally consistent with the model's allometric relationships and growth functions, will be done.

1.1.3 Adaptation to the landscape scale

Landscape level estimates of timber production will be calculated based on the total area within each CSA that is covered by each stand type.

1.2 Timber volume harvested by species and diameter class

1.2.1 Definition

Total annual volume of harvested timber separated by species and diameter class ($\boldsymbol{TVH_{species,\ DBH}}$).

1.2.2 Description

Units: $m^3ha^{-1}yr^{-1}$.

If a model does not calculate timber production in $m^3ha^{-1}yr^{-1}$, a conversion to this unit, using equations that are internally consistent with the model's allometric relationships and growth functions, will be done.

1.2.3 Adaptation to the landscape scale

Landscape level estimates of timber production will be calculated based on the total area within each CSA that is covered by each stand type.

1.2.4 References

Sterba, H., Vospernik, S., Söderbergh, I., Ledermann, Th. 2006. Harvesting Rules and Modules for Predicting Commercial Timber Assortments. In: Hasenauer H. (ed.), Sustainable forest management – growth models for Europe. Springer, Berlin a.o., 111-129.

1.3 Productivity

1.3.1 Definition

Current annual volume increment per hectare (***VI***).

1.3.2 Description

Annually produced stem wood volume = [(stem wood of trees alive at time (i+1) + stem wood of harvested trees in that period + stem wood of trees which died in that period and were not harvested] - stem wood of trees alive at time (i)].

Units: $m^3ha^{-1}yr^{-1}$.

If a model does not calculate timber production in $m^3ha^{-1}yr^{-1}$, a conversion to this unit, using equations that are internally consistent with the model's allometric relationships and growth functions, will be done.

1.3.3 Adaptation to the landscape scale

Landscape level estimates of productivity will be calculated based on the total area within each CSA that is covered by each relevant simulated stand types.

1.4 Stocking

1.4.1 Definition

Stocking volume per hectare of living trees (***V***).

1.4.2 Description

Units: m^3ha^{-1}

If a model does not calculate timber stocking in m^3ha, a conversion to this unit, using equations that are internally consistent with the model's allometric relationships and growth functions, will be done.

1.4.3 Adaptation to the landscape scale

Landscape level estimates of stocking will be calculated based on the total area within each CSA that is covered by each stand types.

1.5 Timber yield by assortment (OPTIONAL)

1.5.1 Definition

Harvested timber by assortments (diameter, length) of round wood and industrial wood by species (***HTA***).

1.5.2 Description

Where available, CSA specific assortment tables will be used. Where such assortments tables are not available, single tree assortment tables from the Austrian timber trade-practices manual (Österreichische Holzhandelsusancen) will be used (see Appendix 1.1 – 1.6).

1.5.3 Adaptation to the landscape scale

Landscape level estimates of stocking will be calculated based on the total area within each CSA that is covered by each stand types.

1.5.4 References

Sterba, H., Vospernik, S., Söderbergh, I., Ledermann, Th. (2006) Harvesting Rules and Modules for Predicting Commercial Timber Assortments. In: Hasenauer H. (ed.), Sustainable forest management – growth models for Europe. Springer, Berlin a.o., 111-129.

Sterba, H., Kleine, M., Eckmüllner, O. 1986. Sortentafeln für Tanne, Lärche, Kiefer und Buche. Österreichischer Agrarverlag, Wien. 182 p. ISBN: 3-7040-0851-6

Sterba, H., Griess, O. 1983. Sortentafeln für Fichte. Österreichischer Agrarverlag, Wien.161 p. ISBN: 3-7040-0766-8

2 Carbon Storage

Above ground and **below ground carbon storage** in living tree biomass will be calculated by all forest models and in all CSAs. In addition, **carbon in dead wood** (standing and coarse woody debris) will be calculated by those models that include these components, while **soil carbon content,** among other system elements**,** will be calculated using the model BIOME-BGC for all CSAs. All carbon storage metrics will be represented in units of **tonnes per hectare (t ha^{-1})**. Corresponding to the wood production metrics, all models that do not natively simulate carbon pools in units of t ha^{-1} will convert their output using algorithms that are internally consistent with the simulated growth and allometric relationships that the model is based on. To aid with this conversion the following sections contain base equations and parameters for calculating forest carbon pools based on forest biomass or wood volume inputs. The conversion equations are taken from IPCC (2006).

By definition, for all carbon indices only trees that are larger than 5 cm DBH are considered.

2.1 Above ground carbon

2.1.1 Definition

Dry mass of carbon contained in above ground living tree biomass (bole + branches + leaves; living trees).

2.1.2 Description

Units: t ha^{-1}.

Calculation of above ground carbon in tree biomass can be done based on inputs of stand biomass (t ha^{-1}), wood volume (m^3 ha^{-1}), or individual tree DBH and heights. The equations used to calculate carbon mass using each of these methods is described below.

2.1.2.1 Stand biomass (t ha-^{1}) method

Above ground stand biomass per hectare is used to calculate above ground carbon stocks (C_{above}). From IPCC (2006):

$$C_{above} = BM_{above} * CF$$

where BM_{above} is the above ground forest biomass (t ha^{-1}) and CF is the carbon fraction of dry matter (t C * t d.m.$^{-1}$) given for broad-leaves or conifers (Table 1).

Table 1: Dry carbon fraction values

Tree type	Carbon dry fraction (CF)
Broad-leaf	0.48
Conifer	0.51
Default	0.50

2.1.2.2 Wood volume (m^3 ha^{-1}) method

Above ground carbon stock is calculated using wood volume by first converting wood volume into above ground biomass (IPCC 2006):

$$C_{above} = [V * D * BEF] * CF$$

where *V* is timber volume (m^3ha^{-1}), *D* is the wood density (t dry matter m^{-3}, Table 2), *BEF* is the biomass expansion factor for conversion of volume to above ground tree biomass (Table 3), and *CF* is the carbon fraction of dry matter (t *C* * t d.m.$^{-1}$) given for broad-leaves or conifers (Table 1).

Table 2: Wood densities of stemwood (tonnes dry matter/m^3 fresh volume)

Species or genus	**Wood density (*D*)**
Abies	0.40
Acer	0.52
Alnus	0.45
Betula	0.51
Carpinus betulus	0.63
Castanea sativa	0.48
Fagus sylvatica	0.58
Fraxinus	0.57
Juglans	0.53
Larix decidua	0.46
Larix kaempferi	0.49
Picea abies	0.40
Picea sitchensis	0.40
Pinus pinaster	0.44
Pinus strobus	0.32
Pinus sylvestris	0.42
Populus	0.35
Prunus	0.49
Pseudotsuga menziesii	0.45
Quercus	0.58
Salix	0.45
Thuja plicata	0.31
Tilia	0.43
Tsuga	0.42

Table 3: Biomass expansion factors (BEF)

Temperate Conifers	1.3
Temperate Broadleaf	1.4
Boreal Conifers	1.35
Boreal Broadleaf	1.3

2.1.2.3 Tree size method (DBH and Height) method

Above ground carbon stock (living trees) is calculated using the equations developed in Vallet *et al.* (2006) for aboveground tree volume (bole + branches)[1]. Above ground tree volume is calculated using tree DBH and height values, and volume is converted to dry carbon mass. Above ground dry carbon is calculated as

$$C_{above} = V_{sp} * D * CF$$

where V_{sp} (m^3) is above ground volume as given by

$$V_{sp} = form \frac{1}{40000\pi} c_{130}^2 * h_{tot}$$

where c_{130} is the circumference in cm at a height of 130 cm, h_{tot} total height in meters and *form* a unitless factor describing a tree's shape. For Norway spruce and Douglas fir trees with a $c_{130} > 45$, *form* is calculated as

$$form = \alpha + \beta * c_{130}$$

and for all other tree species with a $c_{130} > 45$ it is calculated as

$$form = \alpha + \beta * c_{130} + \gamma * hdn$$

where α, β, and γ are species specific constants (Table 4) and *hdn* is a measure of a tree's hardness as given by

$$hdn = \frac{\sqrt{c_{130}}}{h_{tot}}$$

For Douglas fir, Beech, Scots pine, and Maritime pine trees with a $c_{130} < 45$, *form* is calculated as

[1] Bole volume can be derived from total aboveground volume using equations developed in Longuetaud et al. (2013). Modeling volume expansion factors for temperate tree species in France. Forest Ecology and Management 292 : 111-121.

$$form = (\alpha + \beta * c_{130} + \gamma * hdn)\left(1 + \frac{\delta}{c_{130}^2}\right)$$

For other species this small tree correction factor is not used.

Table 4: Parameters for tree volume calculations (from Vallet *et al.*, 2006)

Species	α	β	γ	δ
Sessile oak	0.471	-0.000345	0.377	
Douglas fir	0.534	-0.000530		56.6
Norway spruce	0.631	-0.000946		
Common beech	0.395	0.000266	0.421	45.4
Scots pines	0.297	0.000318	0.384	204.0
Maritime pines	0.235	0.000970	0.396	198.8
Silver fir	0.550	-0.000749	0.277	

2.1.3 Adaptation to the landscape scale

Landscape level estimates of above ground carbon will be calculated based on the total area within each CSA that is covered by each relevant simulated stand types.

2.1.4 References

Nabuurs, G.-J. *et al.* 2003. LUCF sector good practice guidance. Chapter 3 of Penman, J. et al. (eds.), Good practice guidance for land use, land use change and forestry. Special Report of the IPCC, WMO, Geneva;

http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/GPG_LULUCF_FULL.pdf

2006 IPCC Guidelines for National Greenhouse Gas Inventories

http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html

Vallet, P., Dhôte, J.-F., Moguédec, G.L., Ravart, M., Pignard, G. 2006. Development of total aboveground volume equations for seven important forest tree species in France. Forest Ecology and Management 229: 98-110.

2.2 Below ground carbon

2.2.1 Definition

Dry mass of carbon contained in below ground tree biomass.

2.2.2 Description

Units: t ha^{-1}.

For models that do not explicitly simulate below ground carbon the below ground component can be estimated based on the above ground dry carbon mass using IPCC root-to-shoot ratios:

$$C_{below} = C_{above} * R$$

where R is the root-to-shoot ratio (Table 5).

Table 5: Root-to-shoot ratios for estimating below ground carbon mass

Forest type	Root-to-shoot
Temperate conifer (above ground biomass <50 t/ha)	0.40
Temperate conifer (above ground biomass 50-150 t/ha)	0.29
Temperate conifer (above ground biomass >150 t/ha)	0.20
Temperate Quercus (above ground biomass >70 t/ha)	0.30
Temperate broadleaf (above ground biomass <75 t/ha)	0.46
Temperate broadleaf (above ground biomass 75-150 t/ha)	0.23
Temperate broadleaf (above ground biomass >150 t/ha)	0.24
Boreal conifer (above ground biomass <75 t/ha)	0.39
Boreal conifer (above ground biomass >75 t/ha)	0.24

2.2.3 Adaptation to the landscape scale

Landscape level estimates of below ground carbon mass will be calculated based on the total area within each CSA that is covered by each relevant simulated stand types.

2.2.4 References

Nabuurs, G.-J. *et al.* 2003. LUCF sector good practice guidance. Chapter 3 of Penman, J. et al. (eds.), Good practice guidance for land use, land use change and forestry. Special Report of the IPCC, WMO, Geneva

http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/GPG_LULUCF_FULL.pdf

2006 IPCC Guidelines for National Greenhouse Gas Inventories

http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html

2.3 Dead wood carbon (standing and coarse woody debris) (OPTIONAL)

2.3.1 Definition

Dry mass of carbon in dead wood. It concerns standing dead trees with dbh ≥ 5cm and coarse woody debris (originated from trees with dbh ≥ 5cm).

2.3.2 Description

Units: t ha^{-1}.

For models that do not explicitly simulate the dynamics of dead wood, but do contain a pool for the mass or volume of dead wood in a stand, the following equations can be used to calculate the rate at which dead wood and coarse woody debris decomposes into the Soil Organic Matter (SOM) pool. Separate decomposition rates are specified for the tree bole, branches and leaves (Schumacher *et al.*, 2006; Mackensen et al. 2003; Meentemeyer 1978; Harmon et al. 1986).

$$DeadBole_t = DeadBole_{t-1} * \left(1 - 0.0166 * e^{(0.093 * Temp_{annual})}\right)$$

where $Temp_{annual}$ is mean annual temperature.

$$DeadBranch_t = DeadBranch_{t-1} * \left(1 - \left(\left(1 - 0.0166 * e^{(0.093 * Temp_{annual})}\right) * 5\right)\right)$$

$$DeadFoliage_t = DeadFoliage_{t-1} * \left(1 - \left(-1.31369 + 0.0535 * (AET * 10) + 0.18472 * (AET * 10) * LLC\right) * 0\right.$$

where LLC is the Leaf Lignin Content of leaves and is approximated as 0.05, and AET is annual actual evapotranspiration.

2.3.3 Adaptation to the landscape scale

Landscape level estimates of below ground carbon mass will be calculated based on the total area within each CSA that is covered by each relevant simulated stand types.

2.3.4 References

Mackensen, J., Bauhus, J., Webber, E. 2003. Decomposition rates of coarse woody debris – A review with particular emphasis on Australian tree species. Aust. J. Bot. 51: 27–37.

Meentemeyer, V. 1978. Macroclimate and lignin control of litter decomposition rates. Ecology 59: 465–472.

Harmon, M.E., Franklin, J.F., Swanson, F.J. *et al.* 1986. Ecology of coarse woody debris in temperate ecosystems. Adv. Ecol. Res. 15: 133–300.

Schumacher, S., Reineking, B., Sibold, J., Bugmann, H. (2006) Modeling the impact of climate and vegetation on fire regimes in mountain landscapes. Landscape Ecology, 21, 539-554.

2.4 Soil Carbon

2.4.1 Definition

Dry mass of carbon contained in soil organic material.

2.4.2 Description

Units: t ha^{-1}.

Calculation of soil carbon will be done using the model BIOM-BGC for all case study regions. Soil depth must be known for any soil C output.

2.4.3 Adaptation to the landscape scale

Landscape level estimates of soil carbon mass will be calculated based on the total area within each CSA that is covered by each relevant simulated stand types.

2.4.4 Notes

Soil carbon stocks will only be estimated by those models that explicitly account for soil respiration and soil carbon dynamics.

3 Wood Energy

The demand for wood energy is increasing in many countries, justifying the need to take this ecosystem service into account. However, In ARANGE it is considered as optional as it does not concern all case studies areas.

3.1 Above ground wood energy biomass: gross and net amounts

3.1.1 Definition

Above ground forest biomass that remains after timber harvest (the latter typically sawn timber and pulp wood), i.e., total above ground biomass excluding the extracted part of the tree bole. The gross amount (total potential available) and net amount (the amount extractable in practice) have to be specified.

3.1.2 Description

Units: t ha^{-1}.

3.1.3 Adaptation to the landscape scale

Landscape level estimates of above ground wood energy will be calculated based on the total area within each CSA that is covered by each relevant simulated stand types.

3.1.4 Discussion

The amount of above ground forest biomass remaining after harvest will depend on how harvests are simulated and what the forest model intrinsically assumes regarding how waste material is dealt with. Gross available wood energy biomass and net available, i.e., what is practically extractable, have to be specified. Net availability depends on the technique used for extraction, among others. Gross availability can – as in the Swedish HEUREKA system – be estimated using biomass functions (*c.f.* the section on carbon storage) estimating total above ground biomass as the sum of the different tree fractions and then excluding biomass in part of the tree bole extracted in timber harvest. When estimating the net (practically extractable) wood energy biomass, it has first to be stated in what harvest operations extraction is performed, e.g., final felling, thinning and selective felling. Then the net available wood energy biomass is estimated using extraction factors stating the proportion of gross available biomass that is extracted. In HEUREKA, two factors are used, one for the top (above the part of the bole extracted as timber) and one below top. The reason is that branches are still fastened to the bole in the top – i.e., easily extracted – and thereby the proportion of extracted branches and foliage are higher for the top than below the top. Typical extraction factors (%) in HEUREKA, i.e., in Swedish forestry where wood energy biomass extraction is widely practiced, are for the bole top 100, for the branches in the bole top 90, branches below the top 75, foliage in the bole top 50 and foliage below the top 25. Biomass not extracted has to be considered in carbon turnover models (e.g., BIOME-BGC). For models that assume that a parat of the harvested bole, branches, and foliage remain on site, the rate at which this material decomposes should be taken from the Dead Wood Carbon equations defined above.

4 Biodiversity conservation

The importance of including biodiversity aspects in forest management has been recognised in international political processes (Baskent & Keles, 2005; MCPFE, 2003), and management guidelines and practices have been defined to better conserve biodiversity in managed forests (through silviculture, timber harvesting etc.). For instance, dead tree retention, retention of trees with specific microhabitats (e.g. cavities) and tree species mixtures are proposed to improve habitat quality for forest-dwelling species. In ARANGE, the aim is to define a set of indices related to biodiversity that will allow partners to assess the efficiency of biodiversity conservation for different management scenarios at stand and landscape scales. All these indices can be implemented in most models used in ARANGE. When some models are not able to implement an index, it is mentioned in the description section.

4.1 Tree species diversity

4.1.1 Definition and justification

Tree species diversity represents a direct biodiversity index. It is considered as a major feature of forest structure (Pommerening, 2002) and may influence forest functioning (see discussion in Nadrowski *et al.*, 2010). It also impacts other forest biodiversity components such as floristic diversity (e.g. Zilliox & Gosselin, *in press*).

4.1.2 Description

A widely used index to assess tree species diversity at the stand level is Shannon's entropy index, H (Neuman & Starlinger, 2001), which takes into account the number of species in the stand and their relative abundance (by number of trees, basal area, biomass, volume, etc.). In ARANGE, the focus will be on species-specific basal area, for which it is defined as follows (living trees with a dbh ≥ 5cm):

$$\begin{cases} H = -\sum_{i=1}^{S} p_i \ln(p_i) \\ p_i = \dfrac{g_i}{G} \end{cases}$$

with S the number of species, g_i the basal area of species i (m^2)and $G = \sum_{j=1}^{S} g_j$ (m^2).

Actually, Jost (2006) advises the use of the related true diversity index ***D*** which is defined as:

$$D = \exp(H)$$

This index can be interpreted as an "equivalent number of species" as it equals tree species richness when all species in the stand share the same abundance. Otherwise, it is always inferior to tree species richness (and superior or equal to 1). ***D*** **is the index that should be calculated in ARANGE at the stand scale.**

4.1.3 Adaptation to the landscape scale

At the landscape scale, we can apply the classic decomposition of α-diversity, β-diversity and γ-diversity for the Shannon entropy index (Jost, 2007):

$$H_\alpha + H_\beta = H_\gamma$$

This equation can be easily adapted to true diversity indices (Jost, 2007):

$$\exp(H_\alpha).\exp(H_\beta) = \exp(H_\gamma)$$

$$\Rightarrow D_\alpha.D_\beta = D_\gamma$$

In the ARANGE project, we view a landscape as being composed of a mosaic of representative stands of different areas with different management prescriptions, and thus different stand structure at the end of the simulation. Let A_k $k \in [1, N]$ be the areas in hectares of the N polygons of the landscape (representative landscape or virtual landscape). At the landscape scale (total area A), we have (see Jost 2007 for the use of weights):

$$\begin{cases} H_\alpha = \sum_{k=1}^{N} w_k H_k \\ w_k = \dfrac{A_k}{A} \end{cases}$$

$$\begin{cases} H_\gamma = -\sum_{i=1}^{S} P_i \ln(P_i) \\ P_i = \sum_{k=1}^{N} w_k p_{ik} \text{ with } p_{ik} = \frac{g_{ik}}{\sum_{j=1}^{S_k} g_{jk}} \end{cases}$$

Once H_α and H_γ have been calculated, we can easily derive D_α, D_γ and D_β with the equation given above. **D_α, D_β and D_γ are the first type of diversity indices that should be calculated in ARANGE at the landscape scale.**

These indices allow for characterizing the diversity at different scales, but they provide little information on the distribution of diversity values in the landscape. It is also relevant to identify host spots of tree species diversity as well as areas with very poor tree species diversity (e.g. pure stands). Thus, the distribution of D will be considered using three indices: 10%, 50% and 90% weighted percentiles (weights = polygon areas). These three indices will allow us to assess the mean state of the landscape (as D_α) as well as the presence of very high or very low values of tree species diversity in the landscape. Percentiles are preferred over classic mean and variance metrics because the latter are not very informative when distributions of index values in polygons are strongly left- or right-skewed. **$D_{10\%}$, $D_{50\%}$, $D_{90\%}$ are the second type of indices that should be calculated in ARANGE at the landscape scale.**

4.1.4 Discussion

All models can easily implement this set of indices. However, one difficulty with tree diversity indices is to define a common area to allow for comparisons between simulated or observed tree communities across CSAs. That is, the species-area relationship must be controlled for. In ARANGE, this may not be a key problem because most growth models simulate tree communities on a basic unit (typically, 1000 m^2 up to 1 ha) that are considered as being representative of polygons in the real landscape. However, this issue may potentially arise in the RST initialisation process, as the data used are based on plots of different sizes between CSAs. Some discrepancies could arise between simulations of different models depending on the assumptions regarding seed availability in the landscape.

4.1.5 Other optional indices related to species diversity

For biodiversity, it can be also relevant to use groups of species instead of individual species. In this case, we advise to group species according to their family taxonomic level (*Pinaceae*, *Fagaceae*, *Aceraceae*, *Rosaceae*, *Betulaceae*, *Malvaceae* etc.).

Functional diversity can be also considered. There are numerous functional traits that can be used (wood density, specific leaf area, maximum height, leaf size etc.) but we suggest the use of an integrative functional characteristic: species shade tolerance. Niinemetz & Valladares (2006) defined a score of shade tolerance for most tree species listed in Table 6 (see archives at http://www.esapubs.org/archive/mono/M076/020/appendix-A.htm). Then, at the stand scale one can apply Rao's Quadratic Entropy index (Ricotta & Szeidl, 2009):

$$Q = \sum_{i=1}^{S} \sum_{j=1}^{S} d_{ij} p_i p_j$$

where d_{ij} is the dissimilarity between species i and j (here the absolute difference between species shade tolerance scores; d_{ij} can be normalized between [0,1] by dividing it by the maximum difference between species represented in the landscape), p_i and p_j the relative abundances of species i and j (see equations above). This index can be transformed into an equivalent number of species, allowing to partition diversity into alpha, beta and gamma diversities at the landscape scale (see Ricotta & Szeidl, 2009).

4.1.6 Key references

Baskent, E.Z., Keles, S. 2005. Spatial forest planning: A review. Ecological Modelling 188:145-173.

Jost, L. 2006. Entropy and diversity. Oikos 113: 363–375.

Jost, L. 2007. Partitioning diversity into independent alpha and beta components. Ecology 88: 2427-2439.

MCPFE. 2003. Improved Pan-European indicators for sustainable forest management. Paper presented at the Expert level meeting of the Ministerial Conference on the Protection of Forests in Europe, Vienna, 7-8 October 2002. http://www.mcpfe.org/system/files/u1/publications/pdf/improved_indicators.pdf. Accessed July 2007.

Nadrowski, K., Wirth, C., Scherer-Lorenzen, M. 2010. Is forest diversity driving ecosystem function and service ? Current Opinion in Environmental Sustainibility 2: 75-79.

Neumann, M., Starlinger, F. 2001. The significance of different indices for stand structure and diversity in forests Forest Ecology and management 145: 91-106.

Niinemetz, U., Valladares, F. 2006. Tolerance to shade, drought and waterlogging of temperate northern hemisphere trees and shrubs. Ecological Monographs 76: 521-547.

Pommerening, A. 2002. Approaches to quantify forest structure. Forestry 75: 305-324.

Ricotta, C., Szeidl, L. 2009. Diversity partitioning of Rao's quadratic entropy. Theoretical Population Biology 76: 299-302.

Temperli, C., Zell, J., Bugmann, H. Elkin, C. 2013. Sensitivity of ecosystem goods and services projections of a forest landscape model to initialization data. Landscape Ecology 28: 1337-1352.

Zilliox, C., Gosselin, F. In press. Documenting the identity card of tree species diversity, composition and abundance as indicators of understorey vegetation diversity in French mountain forests: variations of the relationship in geographical and ecological space. Forest Ecology and Management.

4.2 Tree size diversity

4.2.1 Definition and justification

Tree size diversity is often considered in studies relating stand structure to biodiversity (McElhinny *et al.*, 2005). The main idea is that high tree size diversity increases the diversity of habitats for forest-dwelling species (Rouvinen & Kuuluvainen, 2005; Buongiorno *et al.*, 1994; Bagnaresi *et al.*, 2002).

4.2.2 Description

We use here the *post-hoc* index presented in Staudhammer & LeMay (2001) without the species diversity component, which is already represented by another index (see section 4.1). The *post-hoc* index corresponds to the mean of the Shannon entropy indices applied to diameter classes and height classes instead of species:

$$\begin{cases} H_{size} = \dfrac{H_{DBH} + H_H}{2} \\ H_{DBH} = -\displaystyle\sum_{i=1}^{N_{DBH}} \frac{g_i}{G} \ln\left(\frac{g_i}{G}\right) \\ H_H = -\displaystyle\sum_{i=1}^{N_H} \frac{g_i}{G} \ln\left(\frac{g_i}{G}\right) \end{cases}$$

with N_{DBH} and N_H the number of DBH classes and height classes present in the stand, g_i the basal area (m^2) of DBH class or height class i and G the basal area of the stand (m^2).

The major drawback of this index is that it necessitates defining classes for both DBH and heights (contrary for instance to the Gini concentration index). To avoid overweighting one of these variables, the potential number of classes for each component should be approximately the same. For DBH, we will use 5 cm classes, and for height 2 m classes. To be coherent with the production and carbon storage linker functions, we define 5 cm for DBH and 4 m for height as minimum values. ***H_{size}* is the index to be calculated at the stand scale.**

4.2.3 Adaptation to landscape scale

While mean diversity at the stand scale can be low, differences between stands can be high (e.g. different development stages). Conversely, diversity at the stand scale can be high within a homogeneous landscape. Thus, to be able to tackle such phenomena, we will use two types of indices at the landscape scale.

The additive property of the Shannon entropy at the landscape scale can be easily adapted to the case of tree size diversity. We have (for details see equations used for tree species diversity, section 4.1.3):

$$\begin{cases} H_{dbh,\alpha} + H_{dbh,\beta} = H_{dbh,\gamma} \\ H_{h,\alpha} + H_{h,\beta} = H_{h,\gamma} \end{cases}$$

which gives:

$$\frac{H_{dbh,\alpha} + H_{h,\alpha}}{2} + \frac{H_{dbh,\beta} + H_{h,\beta}}{2} = \frac{H_{dbh,\gamma} + H_{h,\gamma}}{2}$$
$$\Rightarrow H_{size,\alpha} + H_{size,\beta} = H_{size,\gamma}$$

$H_{size,\alpha}$, $H_{size,\beta}$, $H_{size\gamma}$ is the first set of indices to be calculated at the landscape scale.

Here, we suggest also to use the 10%; 50% and 90% weighted percentiles of H_{size} (weights=polygon areas). **$H_{size,10\%}$, $H_{size,50\%}$, $H_{size,90\%}$ is the second set of indices to be calculated at the landscape scale.**

4.2.4 Discussion

All models within ARANGE are able to compute these indices. The quantitative relationship between tree size diversity and biodiversity is usually unknown. As a consequence, it is difficult to interpret absolute values of this index. We advise thus to use indices related to size diversity in a qualitative way (i.e. hierarchy between stands according to the index (see for instance Redon *et al.* submitted); temporal dynamics of the index, e.g. the index increases or decreases depending on the management scenario applied).

4.2.5 Key references

Bagnaresi, U., Giannini, R., Grassi, G., Minotta, G., Paffetti, D., Pini Prato, E. *et al.* 2002 Stand structure and biodiversity in mixed, uneven-aged coniferous forests in the easthern Alps. Forestry 75: 357-364.

Buongiorno, J., Dahir, S., Lu, H.-C., Lin, C.-R. 1994 Tree size diversity and economic returns in uneven-aged forest stands. Forest Science 40: 83-103.

McElhinny, C., Gibbons, P., Brack, C., Bauhus, J. 2005 Forest and woodland stand structural complexity: Its definition and measurement. Forest Ecology and Management 218. 1-24.

Redon, M., Luque, S., Gosselin, F., Cordonnier, T. Structural attributes beneficial to biodiversity within a forest landscape mosaic: what are the relative contributions of different stand types? Submitted.

Rouvinen, S., Kuuluvainen, T. 2005 Tree diameter distributions in natural and managed old Pinus sylvestris-dominated forests. Forest Ecology and Management 208: 45-61.

Staudhammer, C.L., LeMay, V.M. 2001 Introduction and evaluation of possible indices of stand structural diversity. Canadian Journal of Forest Research 31: 1105-1115.

4.3 Dead wood abundance and diversity

The dead wood compartment is of major importance for forest biodiversity (Lassauce *et al*., 2011). It is influenced by many features of forest management (cf. Bouget *et al*., 2012; Larrieu *et al*., 2012; Siitonen *et al*., 2000; Simila *et al*., 2003). In ARANGE, two indices related to dead wood are calculated. The first one deals with the total abundance of dead wood, which is implemented by most models using various algorithms. The second one focuses on a specific compartment: the abundance of large standing dead trees. This latter index implies some developments in several models.

4.3.1 Dead wood abundance

4.3.1.1 Definition and justification

Dead wood volume is often considered a good surrogate for the diversity of saproxylic species (Martikainen *et al*., 2000; Grove 2002) as it provides habitats as well as resources for these species (Müller & Butler, 2010; Müller *et al*., 2008). Moreover, it is directly related to tree removal and tree retention practices, and as such constitutes a cornerstone to deal with the trade-off between timber production and biodiversity conservation. Although a recent study revealed that the correlation between saproxylic species richness and dead wood volume may not be high in temperate forests (Lassauce *et al*., 2011), probably due to a lack of potential species due to strong past human footprint, it is still used in many countries as an indirect indicator of biodiversity.

4.3.1.2 Description

The dead wood volume *DWV* (m^3ha^{-1}) includes standing dead trees with DBH ≥5 cm and lying dead wood originating from trees with DBH ≥ 5 cm whatever the decomposition stage. It does not contain stumps. In the ARANGE project, most models have an algorithm to compute dead wood volume. For the sake of simplicity, we let growth models use their own algorithm to produce this index. For the PICUS model, when possible, we will use the carbon pool of standing and lying deadwood (t C ha^{-1}) instead of the total dead wood volume. ***DWV* (m^3ha^{-1}) is the index to be used in ARANGE at the stand level.**

4.3.1.3 Adaptation to landscape scale

We can use 10%, 50% and 90% weighted percentiles to characterize dead wood volume distribution in representative or virtual landscapes. **$DWV_{10\%}$, $DWV_{50\%}$, $DWV_{90\%}$ is the first set of indices at the landscape scale.**

The quantitative relationship between dead wood volume and saproxylic species diversity is usually unknown. As dead wood can be considered as a resource as well as a habitat for some species we suggest using also a minimum threshold value to define an index at the landscape scale. Let be *X* this threshold, we can define:

$$A_X = \frac{100}{A}\sum_{i=1}^{N} A_i k_i \begin{cases} k_i = 0 \text{ if } DWV_i < X \\ k_i = 1 \text{ if } DWV_i \geq X \end{cases}$$

where A_X (%) is the percentage of the area with dead wood volume per hectare superior to *X*, *N* the number of polygons in the landscape, A_i (ha) the area of polygon *i*, *A* (ha) the area of the landscape, and DWV_i (m^3ha^{-1}), the dead wood volume per hectare in the polygon *i.*

The *X* value can depend on the case study area (boreal/temperate/mediterranean). We can set *X* according to expert assessments (for instance X=30m^3ha^{-1} in temperate forest ecosystems, X=20m^3ha^{-1} in boreal and mediteranean forest ecosystems). To allow comparisons between landscape scenarios, we can use the relationship between A_X and *X* (see a theoretical case figure 1) or even the quantile corresponding to *X*. **A_X (%) is the second type of index at the landscape scale. The threshold value *X* (m^3h^{-1}) must be adapted to case study areas.**

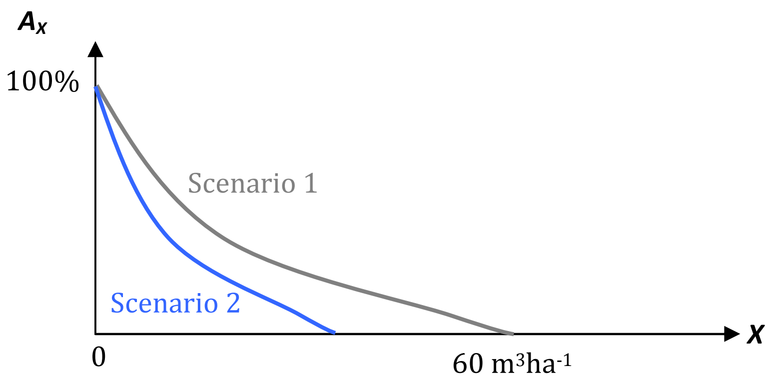


Figure 1: relationship between the threshold value *X* and the percentage of landscape area that is above this threshold for two different scenarios.

4.3.1.4 Discussion

As this indicator is calculated by different algorithms, it will be important to identify main differences between models to get relevant interpretations of results in the different CSAs.

4.3.1.5 Key references

Bouget, C., Lassauce, A., Jonsell, M. 2012. Effects of fuelwood harvesting on biodiversity - a review focused on the situation in Europe. Canadian Journal of Forest Research 42: 1421-1432.

Grove, S.J. 2002. Tree basal area and dead wood as surrogate indicators of saproxylic insect faunal integrity: a case study from the Australian lowland tropics. Ecological Indicators 1: 171-88.

Larrieu L, Cabanettes A, Delarue A. 2012. Impact of silviculture on dead wood and on the distribution and frequency of tree microhabitats in montane beech-fir forests of the Pyrenees. European Journal of Forest Research 131: 773-786.

Lassauce, A., Paillet, Y., Jactel, H., Bouget, C. 2011. Deadwood as a surrogate for forest biodiversity: Meta-analysis of correlations between deadwood volume and species richness of saproxylic organisms. Ecological Indicators 11: 1027-1039.

Martikainen, P., Siitonen, J., Punttila, P., Kaila, L., Rauh, J. 2000. Species richness of Coleoptera in mature managed and old-growth boreal forests in southern Finland. Biological Conservation 94: 199-209.

Müller, J., Butler, R. 2010. A review of habitat thresholds for dead wood: a baseline for management recommendations in European forests. European Journal of Forest Research 129: 981-992.

Müller, J., Bussler, H., Kneib, T. 2008. Saproxylic beetle assemblages related to silvicultural management intensity and stand structures in a beech forest in Southern Germany. Journal of Insect Conservation 12:107-124

Siitonen J, Martikainen P, Punttila P, Rauh J. 2000. Coarse woody debris and stand characteristics in mature managed and old-growth boreal mesic forests in southern Finland. Forest Ecology and Management 128: 211-225.

Simila M, Kouki J, Martikainen P. 2003. Saproxylic beetles in managed and seminatural Scots pine forests: quality of dead wood matters. Forest Ecology and Management 174: 365-381

4.3.2 Abundance of large standing dead trees

4.3.2.1 Definition and justification

The total abundance of dead wood is insufficient to assess biodiversity of saproxylic species (Lassauce *et al*., 2011). The diversity of dead wood pieces plays also a role (Müller *et al*., 2008; Brin *et al*., 2009; Simila *et al*., 2003). Thus, it is important either to consider an index that allow quantifying diversity of dead wood pieces (size, the species, position (standing/lying), decomposition stages) or to target a specific component of dead wood such as standing dead wood or large woody debris. Standing dead trees (snags) contain more microhabitats for saproxilic species than living trees (Vuidot *et al*., 2011; Fan *et al*., 2003) and provide specific habitats for some species compared to lying dead wood.

4.3.2.2 Description

The abundance of large standing dead trees is defined here as the number of trees per hectare with a DBH superior or equal to D_{LSD} cm for both conifers and broadleaves.

$$LSDTN = \sum_{i=1}^{n} k_i \quad \begin{cases} k_i = 1 \text{ if } DBH_i \geq D_{LSD} \\ k_i = 0 \text{ if } DBH_i < D_{LSD} \end{cases}$$

Actually, only PICUS (Seidl *et al*., 2007), SAMSARA2 (based on work of Holeska *et al*. 2008) and STANDWISE models are able to simulate standing dead trees. Here, we suggest implementing the PICUS algorithm in other models. In PICUS, for each tree species there is an annual probability for the downing of a dead tree (p_d). For instance, in the case of Norway spruce p_d=0.103 per year. These probabilities have been derived from literature values by researchers from BOKU. Here are the values for the most important species:

Table 6: Annual probability of dead tree downing for most important species

Norway spruce Silver fir European larch	European beech	Scots pine	Sycamore maple Common ash Birch	Pedunculate oak	Swiss stone pine
0.103	0.224	0.081	0.142	0.141	0.045

Once these probabilities have been implemented in the growth model, one can calculate at each time step the number of large standing dead trees per hectare. These probabilities can be modulated in CSA according to expert knowledge or some available data. ***LSDTN* is the index at the stand scale. By default D_{LSD}=30cm. It can be adapted to case study areas and possibly according to species type (conifers or broadleaves).**

4.3.2.3 Adaptation to the landscape scale

We suggest using the 10%, 50% and 90% weighted quantiles. ***$LSDTN_{10\%}$*, *$LSDTN_{50\%}$*, *$LSDTN_{90\%}$* is the first set of indices at the landscape scale**.

We can also apply the same approach as the dead wood abundance by defining a minimum threshold values. Let be *X* this threshold, we can define:

$$A_X = \frac{100}{A}\sum_{i=1}^{N} A_i k_i \begin{cases} k_i = 0 \text{ if } LSDTN_i < X \\ k_i = 1 \text{ if } LSDTN_i \geq X \end{cases}$$

where A_X (%) is the percentage of area with the number of large standing dead trees per hectare superior to *X*, *N* the number of polygons in the landscape, A_i (ha) the area of polygon *i* and $LSDTN_i$, the number of large standing dead trees in the polygon *i*.

We can set *X* according to expert assessments (for instance *X*=2ha^{-1}). To compare between landscape scenarios, we can use the relationship between A_X and *X* or even the quantile corresponding to *X* (cf. §4.3.1.3). **A_X is the second type of index retained at the landscape scale.**

4.3.2.4 Discussion

For the diameter threshold D_{LSD}, some adaptations to specific CSA can be considered.

4.3.2.5 Other optional index related to dead wood

For models that have a detailed model of dead wood dynamics (decaying), we suggest also to use an index of dead wood diversity based on the following principles (Brin *et al.*, 2011):

- Defining categories of dead wood based on dead wood pieces size (ex. diameter classes), species type (conifers/broadleaves), decaying stages (e.g. 5 classes) and position (standing/lying, stumps).

- Calculating the abundance (number, volume, biomass) of dead wood pieces in each category.

- Calculating the number of represented categories, i.e. categories which have a minimum amount of dead wood (e.g. 1 m3ha-1).

The number of represented categories is an index of the diversity of dead wood pieces in the stand.

4.3.2.6 References

Brin, A., Bouget, C., Brustel, H., Jactel, H. 2011. Diameter of downed woody debris does matter for saproxylic beetle assemblages in temperate oak and pine forests. Journal of Insect Conservation 15: 653-669.

Fan, Z.F., Shifley, S.R., Spetich, M.A., Thompson, F.R., Larsen, D.R. 2003. Distribution of cavity trees in midwestern old-growth and second-growth forests. Canadian Journal of Forest Research 33:1481-1494

Gossner, M.M., Floren, A., Weisser, W.W., Linsenmair, K.E. (2013) Effect of dead wood enrichment in the canopy and on the forest floor on beetle guild composition. Forest Ecology and Management 302:404-413

Holeksa, J., Zielonka, T., Zywiec, M. 2008. Modeling the decay of coarse woody debris in a subalpine Norway spruce forest of the West Carpathians, Poland. Canadian Journal of Forest Research 38:415-428

Lachat, T., Wermelinger, B., Gossner, M.M., Bussler, H., Isacsson, G., Muller, J. (2012) Saproxylic beetles as indicator species for dead-wood amount and temperature in European beech forests. Ecol Indic 23:323-331

Müller J., Bussler, H., Kneib, T. 2008. Saproxylic beetle assemblages related to silvicultural management intensity and stand structures in a beech forest in Southern Germany. Journal of Insect Conservation 12: 107-124.

Seidl, R., Rammer, W., Jäger, D., Currie, W.S., Lexer, M. 2007. Assessing trade-offs between carbon sequestration and timber production within a framework of multi-purpose forestry in Austria. Forest Ecology and Management 248 : 64-79.

Vuidot, A., Paillet, Y., Archaux, F., Gosselin, F. 2011 Influence of the tree characteristics and forest management on tree microhabitats. Biological Conservation 144: 441-450.

4.4 Abundance of large living trees

4.4.1 Definition and justification

Trees with large diameter are known to contain more microhabitats (i.e. cavities, dead branches) than smaller trees (Vuidot *et al.*, 2011 ; Larrieu & Cabanettes, 2012 ; Nilsson *et al.*, 2002 ; Michel & Winter, 2009 ; Winter & Möller, 2008). Some studies found that the probability of carrying a microhabitat is low for trees with DBH <30 cm (Vuidot *et al.*, 2011; Fan *et al.*, 2003; Schreiber *et al.*, 1992) or DBH <40 cm (Larrieu *et al.*, 2012; Larrieu & Cabanettes, 2012). Several studies suggest that the probability and abundance of micro-habitats increases with DBH, with a significant threshold around 60-70cm, depending on the species. Although a clear threshold is observed at DBH 70 cm for conifers (Larrieu *et al.*, 2012; Michel & Winter, 2009; Schreiber & deCalesta, 1992), there seems to be more variability for broadleaves, with values around 50 cm (Lachat & Butler, 2007), 70 cm (Larrieu *et al.*, 2012) and 90 cm (Larrieu & Cabanettes, 2012).

4.4.2 Description

The abundance of large living trees is defined here as the number of trees per hectare with a DBH above D_{LLC} cm for conifers (e.g. 70 cm) and D_{LLB} cm for broadleaves (e.g. 50 cm).

$$LLTN = \sum_{i=1}^{n} k_i \quad \begin{cases} k_i = 1 \text{ if } DBH_i \geq D_{LLC} \text{ or } DBH_i \geq D_{LLB} \\ k_i = 0 \text{ if } DBH_i < D_{LLC} \text{ or } DBH_i \geq D_{LLB} \end{cases}$$

***LLTN* is the index at the stand scale.** The *DBH* limits for broadleaves and conifers must be adapted to the CSAs, as maximum tree dimensions differ by species and with climate.

4.4.3 Adaptation to the landscape scale

We use the 10%, 50% and 90% weighted quantiles. **$LLTN_{10\%}$, $LLTN_{50\%}$, $LLTN_{90\%}$ is the first set of indices to be calculated at the landscape scale**.

We can use the same approach as for dead wood abundance by defining minimum threshold values. Let be X this threshold, we define:

$$A_X = \frac{100}{A} \sum_{i=1}^{N} A_i k_i \begin{cases} k_i = 0 \text{ if } LTN_i < X \\ k_i = 1 \text{ if } LTN_i \geq X \end{cases}$$

where A_X (%) is the percentage of area with the number of large living trees per hectare above X, N the number of polygons in the landscape, A_i (ha) the area of polygon i and LTN_i, the number of large living trees in polygon i.

We can set X according to expert assessments (e.g., X = 2 ha^{-1}). To allow for comparisons between landscape scenarios, we can use the relationship between A_X and X or even the quantile corresponding to X. **A_X is the second type of index to be used at the landscape scale.**

4.4.4 Discussion

The quantitative relationship between abundance of large living trees and biodiversity is usually unknown. As a consequence, it is difficult to interpret absolute values of this index. We advise thus to use indices related to abundance of large living trees in a qualitative way (i.e. hierarchy between stands according to the index (see for instance Redon *et al.* submitted); temporal dynamics of the index, e.g. the index increases or decreases depending on the management scenario applied).

4.4.5 Key references

Larrieu, L., Cabanettes, A. 2012. Species, live status, and diameter are important tree features for diversity and abundance of tree microhabitats in subnatural montane beech–fir forests. Canadian Journal of Forest Research 42: 1433-1445

Michel, A.K., Winter, S. 2009. Tree microhabitat structures as indicators of biodiversity in Douglas-fir forests of different stand ages and management histories in the Pacific Northwest, USA. Forest Ecology and Management 257: 1453-1464.

Nilsson, S.G., Niklasson, M., Hedin, J., et al. 2002, Densities of large living and dead trees in old-growth temperate and boreal forests. Forest Ecology and Management 161: 189-204.

Schreiber, B., deCalesta, D.S. 1992. The relationship between cavity-nesting birds and snags on clearcuts in western Oregon. Forest Ecology and Management 50: 299-316

Fan, Z.F., Shifley, S.R., Spetich, M.A., Thompson F.R., Larsen D.R. 2003. Distribution of cavity trees in midwestern old-growth and second-growth forests. Canadian Journal of Forest Research 33:1481-1494

Winter, S., Möller, G.C. 2008. Microhabitats in lowland beech forests as monitoring tool for nature conservation. Forest Ecology and Management 255: 1251-1261.

Vuidot, A., Paillet, Y., Archaux, F., Gosselin, F. 2011 Influence of the tree characteristics and forest management on tree microhabitats. Biological Conservation 144: 441-450.

Lachat, T., Butler, R. 2007. Gestion des vieux arbres et du bois mort: Îlots de sénescence, arbres-habitat et métapopulations saproxyliques. Ecole polytechnique fédérale Lausanne (EPFL) - WSL, Lausanne, Suisse.

4.5 Bird habitat quality models

Habitat quality models are complementary to previous indices as they target specific species or specific group of species. Several models have implemented habitat quality scores at the stand scale and the landscape scale. For instance PICUS provides habitat quality scores for the white-backed woodpecker (*Dendrocopos leucotos*) and the Ural owl (*Strix uralensis*), LANDCLIM for the capercaillie (*Tetrao urogallus*) and HEUREKA for the Siberian jay (*Perisorues infaustus*), the hazel grouse (*Bonasa bonasia*) and the lesser spotted woodpecker (*Dendrocopus minor*). Scores are continuous (capercaillie) or based on classes (good, medium, poor; white-backed woodpecker). Some of these indices have been adapted to the landscape scale. In the ARANGE project, the Birdlife partner is developing habitat quality indices based on scientific and expert knowledge.

4.5.1 General scheme for entire Europe

It was agreed in the kickoff meeting of the project, but it was also re-discussed and agreed in the BirdLife's expert meeting that the models should be as universal as possible and not case study area driven. In this way, models can be more objective, while they can also be applied in other areas of Europe.

The forest habitat elements which will be included in the models as parameters should be selected by following the requirements of typical forest bird species. The selected species should have a large distribution, express different types of forest management and behave similarly in Europe. In addition, the parameters should be available within the ARANGE project.

4.5.2 Selecting bird species

Species listed under the Annex I of Birds Directive (Directive 2009/147/EC) were agreed to have a priority when searching for possible typical forest bird species. Furthermore, due to the available data within ARANGE, the possible typical forest bird species should strongly depend on trees and not on shrubs for their survival.

Several options regarding species which relate to the above criteria were examined, but the results were frustrating, mainly due to the species distribution. Therefore, it was concluded to select not individual bird species, but a group of species which have various requirements with common elements and an extended distribution when examined as a group.

The group's common element decided to be their nesting method: they all nest in tree-holes. The reason for selecting this element was that the land use and cover changes due to human actions are the largest hazards for forest birds' biodiversity and populations' viability in Europe, especially to species present in old-growth forests. Actually, in the last years, the cave-dwelling birds are highly considered as good key species and umbrella species for nature conservation and protection.

The selected group of typical forest bird species (see Table 7) consists of all the woodpeckers which are present in the case study areas and one owl (Tengmalm's Owl) which is common for almost all the case study areas. To this group of species, the Eurasian Tree Creeper was added as a forest bird species present to all case studies. The Tree Creeper is much smaller thus less demanding, while it has several similar elements with some woodpeckers. It is also highly depended on the trees' characteristics.

Table 7. Present of the selected species in the case study areas.

	AU	BG	SK	SI	SP
Tengmalm's Owl (*Aegolius funereus*)	+	+	+	+	-
Eurasian Wryneck (*Jynx torquilla*)	-	-	-	-	+
Grey-headed Woodpecker *(Picus canus)*	-	+	+	+	-
European Green Woodpecker *(Picus viridis)*	+	+	-	-	+
Black Woodpecker *(Dryocopus martius)*	+	+	+	+	-
Great Spotted Woodpecker *(Dendrocopos major)*	+	+	+	+	+
Syrian Woodpecker *(Dendrocopos syriacus)*	-	-	-	-	-
Middle Spotted Woodpecker *(Dendrocopos medius)*	-	-	-	-	-
White-backed Woodpecker *(Dendrocopos leucotos)*	-	-	+	+	-
Lesser Spotted Woodpecker *(Dendrocopos minor)*	-	-	-	-	-
Three-toed Woodpecker *(Picoides tridactylus)*	+	+	+	+	-
Eurasian Treecreeper (*Certhia familiaris*)	+	+	+	+	+

4.5.3 Defining indicators for habitat quality models

As general frame for indicator selection the following requirements were considered:

- ✓ measurable and comparable
- ✓ universal so to include all ARANGE project's case study areas
- ✓ consistent with the ARANGE project's data
- ✓ applicable for models and tools of ARANGE

dead wood, standing:

Dying and dead trees have been recognized as a highly important factor for breeding and feeding of numerous animal and plant species. Specifically for the selected bird species group for ARANGE (cave-dwelling birds), the standing dead wood has even more significance.

Standing deadwood (snags) above specific thresholds (see Table 8 below) can be calculated in accordance with the deadwood indicators (see above). Important is that the forest models include the snag dynamics.

unmanaged forests:

The parameter has a similar requirement for nature conservancy as the dead wood. Moreover, in the areas where no forest management occurs, the forest ecosystem is closer to natural processes, so there is usually a balanced nutrient cycling, dead wood, complex structure, etc. which can support high levels of biodiversity.

This is a qualitative indicator which is based on prior knowledge about a specific RST and the sequence of harvest operations which is simulated in a specific management regime. In the ARANGE context just harvest operations (i.e. the removal of biomass after tree cutting) are used to indicate "unmanaged" conditions.

veteran trees:

There is evidence that the diversity and abundance of animal species are higher around veteran trees. The reason is that these trees develop really many micro habitats from the roots to the highest branches of the trees. When veteran trees are missing, then these micro-habitats are decreasing. In addition, often the veteran trees can be connected with the age of the forest stand.

Large trees above specific thresholds (see Table 8) are available from all forest models. Indicator should be calculated in accordance with the large tree indicator for biodiversity (see above).

canopy cover:

The canopy cover is connected to the general structure of the habitat, hence to the overall quality of habitat for birds. Medium cover-range is the most favorable for birds, because these forests have the best food availability (insects, good cover of herb- and shrub-layer), while remaining closed enough for sheltering and nesting. Too dense and too open cover-range conditions are suboptimal for birds for several reasons; mainly because the food availability is reduced.

In most forest models canopy cover is not directly available. This can easily be circumvented by adding a routine which estimates crown diameter for each simulated tree in a stand from DBH. Suitable equations should be accessible for each CSA. No specific prescription is given here.

alien tree species:

It's very difficult to define specific and universal values corresponding to the preferences of bird species to a certain percentage of specific tree species in the forest composition for Europe since the forests (and along with them the birds' preferences) alters extensively in the ARANGE project's case study areas. Therefore, it was decided that the tree species composition as a parameter of the models will only provoke confusions and misunderstandings.

However, it was accepted that mixed forests are better for biodiversity and ecosystem services (more available habitats, more chances for fulfilling birds' requirements) but this mixture should derive from indigenous tree species and not from alien tree species (for which there is no information how they are going to affect the forest ecosystems in a long term perspective).

This is why the parameter of "presence of alien tree species" was selected instead of "tree species composition".

4.5.4 Defining thresholds for habitat quality indicators

For the purposes of ARANGE project, the thresholds for each indicator were divided into three classes, entitled as "good", "medium" and "poor".

For the case of the indicator "dead wood, standing", the classes were six, since they are divided into three classes accordingly to their biogeographic region (e.g. the Mediterranean region represented by the case study areas of "Rhodope Mountains" in Bulgaria and "Iberian Mountains" in Spain) and the rest of Europe.

Additionally, the indicator "presence of alien tree species" operates as an exclusion parameter, meaning that the thresholds are divided into two classes ("good" and "poor") according to the percentage of alien tree species presence in the forest stand (Table 2).

Table 8. Presentation of the models' indicators and their thresholds.

No	Indicator	Good	Medium	Poor	Remarks
1	Dead wood, standing (m³/ha); for all regions but the Mediterranean	> 35	15 – 35	< 15	Only for standing dead wood, DBH > 30 cm
	Dead wood, standing (m³/ha); for Mediterranean zones	> 20	10 – 20	< 10	
2	Unmanaged forest (years)	> 100	20 – 100	< 20	If there was any harvest operation within the previous 20 years it's always "poor" regarding this indicator; in condition "good" the stand is approaching "old growth" conditions;
3	Veteran trees (n/ha)	> 20	10-20	<10	Maturity of stands, DBH > 50 cm
4	Canopy cover (%)	60 – 80	80 – 90 and 40 – 60	> 90 or < 40	Characterizes forest conditions of intermediate crown closure; if too dense no suitable ground layer will develop, if too open no forest microclimate will prevail;
5	Tree species (basal area of alien tree species)	< 10 %		> 10 %	

4.5.5 Aggregation of indicators at the stand level

The application of the bird habitat quality models at the forest stand level includes the aggregation of the parameters "dead wood", "unmanaged forest", "veteran trees" and "canopy cover" (No 1 - 4) by following these rules:

- ✓ Stand is good if more than 2 parameters are classified as good
- ✓ Stand is medium if more than 2 parameters are classified as medium or good
- ✓ Stand is poor if the criteria for good or medium are not fulfilled

If the parameter "presence of alien tree species "is poor, then the forest stand is directly characterized as "poor".

4.5.6 Habitat quality at the landscape scale

Two approaches are proposed to assess habitat quality at landscape scale. Both options should be implemented. Option A can be directly calculated from stand level results, Option B requires some post hoc processing in a GIS environment.

Option A

Each forest landscape is rated according to the area that is covered by good, medium or poor stands:

- ✓ If the area of good forest stands covers more than 50%, then it is classified as good
- ✓ If the area of medium forest stands or of mixture of good and medium forest stands is covering more than 50%, then it is classified as medium (area of good stands cannot exceed 50% cover)
- ✓ Any other combination of good, medium and poor cover of the forest stands is classified as poor

Option B

Option B is based on samples taken from the landscape. The samples are circular of three distinct sizes. These circular samples are distributed over the landscape on a grid and they are depicting the minimum required size of the home range of one breeding pair. The three sample sizes are:

- 5 ha for species with small home range
- 20 ha for species with medium home range
- 50 ha for species with large home range

  The value (good, medium or poor) of each sample is based on the quality value(s) of the sampled stand polygon(s). The classification of a sample home range is according to option A: good: weighted area share of good is >50%, medium: weighted area share of good and medium is >50%; poor: other combinations

Each forest landscape is classified according to its proportion of good, medium or poor samples. The rules for this classification are similar to the rules for classifying forest stands (pls. check chapter 5).

- ✓ If the proportion of good samples is more than 50%, then the landscape is classified as good
- ✓ If the proportion of medium samples or of mixture of good and medium samples is more than 50%, then the landscape is classified as medium (proportion of good samples cannot exceed 50%)
- ✓ Any other combination of good, medium and poor samples is classified as poor landscape

4.5.7 Discussion

For a discussion and details see Kourakli *et al*. (2013)

4.5.8 References

Angelstam, P.; R. Bütler; M. Lazdinis; G. Mikusinski & J.M. Roberge (2003): Habitat thresholds for focal species at multiple scales and forest biodiversity conservation – dead wood as an example. Ann. Zool. Fennici 40: 473-482.

Bütler, R.; P. Angelstam; P. Ekelund & R. Schlaepfer (2004): Dead wood threshold values for the three-toed woodpecker presence in boreal and sub-Alpine forest. Biological Conservation 119: 305-318.

Carlson, A. (2000). The effect of habitat loss on a deciduous forest specialist species: the White-backed Woodpecker (Dendrocopos leucotos). *Forest Ecology and Management 131* , 215-221.

Drever, M.C.; K.E.H. Aitken; A.R. Norris & K. Martin (2008): Woodpeckers as reliable indicators of bird richness, forest health and harvest. Biological Conservation 141: 624-634.

Dvorak, M. & G. Wichmann (2005): Entwicklung von Kriterien, Indikatoren und Schwellenwerten zur Beurteilung des Erhaltungszustandes der Natura 2000-Schutzgüter. Band 1: Vogelarten des Anhangs I der Vogelschutz-Richtlinie; im Auftrag der neun österreichischen Bundesländer des Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft und der Umweltbundesamt GmbH.

Garmendia, A.; S. Carcamo & O. Schwendtner (2006): Forest management considerations for conservation of Black Woodpecker *Dryocopus martius* and White-backed Woodpecker *Dendrocopos leucotos* populations in Quinto Real (Spanish Western Pyrenees). Biodiversity and Conservation 15: 1399-1415.

Guénette, J.-S. & Villard, M.-A. (2005). Thresholds in Forest Bird Response to Habitat Alteration as Quantitative Targets for Conservation. *Conservation Biology, Volume 19, No. 4, 1168-1180.*

Hakkarainen, H., Korpimäki, E., Laaksonen, T., Nikula, A. & P. Suorsa (2008): Survival of male Tengmalm's owls increases with cover of old forest in their territory. *Oecologia 155, 479-486.*

Kourakli, P. et al. 2013. ARANGE Task 2.2: Habitat quality models. Internal Report.

Moning, C.; H. Bussler & J. Müller (2009): Schlüsselwerte in Bergmischwäldern als Grundlage für eine nachhaltige Forstwirtschaft. Nationalparkverwaltung Bayerischer Wald, Wissenschaftliche Reihe, Heft 19, Grafenau.

Ranius, T. & L. Fahrig (2006): Targets for maintenance of dead wood for biodiversity conservation based on extinction thresholds. Scandinavian Journat of Forest Research 21: 201-208.

Sauberer, N.; E. Hochbichler; N. Milasowsky; N. Panagoitis & L. Sachslehner (2007): Nachhaltiges Waldbiomassenmanagement im Biosphärenpark Wienerwald. Verlag der Österreichischen Akademie der Wissenschaften, Wien, 150 pp.

Suorsa, P., Huhta, E., Jäntti A., Nikula, A., Helle, H., Kuitunen, M., Koivunen, V. & Hakkarainen, H. (2005). Thresholds in selection of breeding habitat by the Eurasian treecreeper (Certhia familiaris). Biological Conservation 121, 443-452.

5 Protection against natural hazards

Many mountain forests cover steep to very steep slopes (angle of 35 - 70°) and thus have an important protective function against natural hazards such as rockfall, snow avalanches, shallow landslides and erosion. The primary function of these protection forests is to protect people or assets from the impacts of natural hazards. The key 'product' of these forests are the standing trees that act as obstacles to the acquisition of the initial conditions necessary to the release of mass movement hazards and/or the downslope propagation of these hazards. For example, 43% of the forests in Switzerland have a protective function, 42.7% in Val d'Aosta, and 29.5% and 24.7% in the French departments of Haute-Savoie and Isère, respectively. In Austria and Germany, the area of forest providing a protective function amounts to 25% and 34%, respectively. In Slovenia the only data available are for forests officially classified as protection forests: 9% of the forested area. For the Northern part of the Alpine Space, protection forests make up ~33% of total forest cover. In Austria and Switzerland alone, approximately 50 million Euros are spent yearly to maintain or improve the protection provided by mountain forests (European Observatory of Mountain Forests 2000; Swiss Federal Statistical Office 2002).

5.1 Protection against rock-falls

5.1.1 Definition and justification

In the case of rockfall, the forest is efficient only in the transit and deposit zones. There, the efficiency of the protection offered by a forest stand against rockfall depends on:

- The volume, the shape and the mass of the boulder.
- The initial fall height.
- The distance between the foot cliff and the entry in the stand.
- The slope.
- The slope roughness and the dominant soil type.
- The length of the forested slope.
- The stand dendrometric parameters: stem density, basal area, mean diameter at breast height (mean DBH), tree species distribution.

These values need to be calculated for each representative stand type (RST, see WP1) or simulated stand to derive a value of the **Probable Residual Hazard (PRH)**. The PRH is equal to the percentage of rocks that are able to pass through and exit a forested slope.

The tool Rockfornet (http://www.ecorisq.org/en/rockfornet.php) calculates this PRH. The PRH uses a statistical approach for calculating the maximal energy developed by a rock. We propose to retain this principle for calculating the **Rockfall Protection Index (RPI)**.

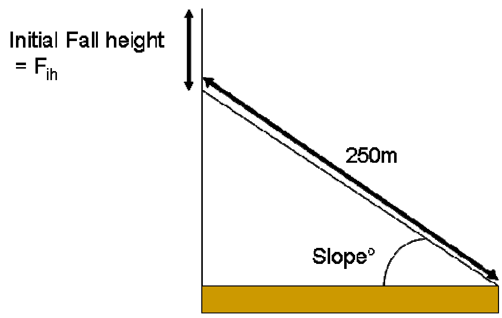
The PRH is calculated for the current stand present on the slope. The general principle for calculating this index is firstly to calculate the **dissipating maximal energy (DME)** developed by the rock (calculated using the energy line principle), which is a function of

- The slope angle.
- The initial fall height.
- The volume and mass of a rock.
- The average diameter at breast height of the current stand.
- The percentages of evergreen species and deciduous ones.

Then, one has to calculate the **current energy dissipation (CED)** ability of the current stand and finally to calculate the ratio CED/DME, which equals PRH.

At the RST scale, we propose to calculate a RPI based on the principle of the PRH for **a pixel corresponding to a distance along the slope of 250 m, which is the minimal distance for which a stand can provide effective protection**. As this calculation will be made for each stand, it will be possible to do a harmonized comparison between stands. The RPI equals to:

$$RPI = 1 - PRH$$



The distance between the foot of the cliff and the entry in the forest is set to 0. The initial fall height is set to 20 meters.

The index also depends on the rock size and rock density. We propose to calculate it for five types of boulders and two rock densities (Table 8).

Table 8: type of boulders used to calculate RPI

<table>
<tr><th>Volume</th><th>Equivalent rock diameter</th><th>Rock density</th></tr>
<tr><td>0.05</td><td>0.46</td><td rowspan="5">2400kg/m³
2800kg/m³
3000kg/m³</td></tr>
<tr><td>0.2</td><td>0.73</td></tr>
<tr><td>1</td><td>1.24</td></tr>
<tr><td>2.5</td><td>1.68</td></tr>
<tr><td>5</td><td>2.12</td></tr>
</table>

5.1.2 Description

Table 9 provides the input data for the calculation of the PRH for one pixel.

Table 9: input data for the calculation of the *PRH* for one pixel type

<table>
<tr><th colspan="3">Forest stand</th><th colspan="3">Topography</th><th colspan="3">Rock</th></tr>
<tr><th>Name</th><th>Abbreviation</th><th>Units</th><th>Name</th><th>Abbreviation</th><th>Units</th><th>Name</th><th>Abbreviation</th><th>Units</th></tr>
<tr><td>Stem density</td><td>N</td><td>Stem/ha</td><td>Slope value</td><td>$slope°$</td><td>degree</td><td>Diameter of the rock</td><td>Φ_{rock}</td><td>m</td></tr>
<tr><td>Average diameter at breast height</td><td>$\overline{DBH}$</td><td>Cm</td><td colspan="3"></td><td>Rock density</td><td>ρ</td><td>Kg/m³</td></tr>
<tr><td>Percentage of evergreen species</td><td>EvG</td><td>%</td><td colspan="3" rowspan="2"></td><td>Initial free fall height</td><td>F_{ih}</td><td>m</td></tr>
<tr><td>Percentage of deciduous species</td><td>DcD</td><td>%</td><td colspan="3"></td></tr>
</table>

- **<u>If $G_{stand} \geq 10m^2/ha$</u>** then the equations for calculating PRH are:

$$A = \frac{(\Phi_{rock} \times N \times 250 \times \cos(slope^{o})) \times (EvG + (DcD \times 1.7)) * 38.7 * \overline{DbH}^{2.31}}{3.352 \times 10^4 \times \left[0.5 \times \rho \times \pi \times \left(\Phi_{rock}/2 \right)^3 \times \left[\min\left(\sqrt{\left(2 \times 9.81 \times \left(F_{ih} + \left(250/\cos(slope^{o}) \right) \right) (\tan(slope)) - 0.6 \right)}; 0.64 \times slope^{o} \right)^2 ; 0.64 \times slope^{o} \right] + 0.25 \times \rho \times \pi \left(\Phi \cdots \right. \right.}$$

$$RPH = \max(0.01; 1 - A)$$

$$RPI = 1 - \max(0.01; 1\text{-}A)$$

- **<u>If $G_{stand} < 10m^2/ha$</u>** then the equation for calculating PRH are:

$$B = \frac{(\Phi_{rock} \times N \times 250 \times \cos(slope^{o})) \times (EvG + (DcD \times 1.7)) * 38.7 * \overline{DbH}^{2.31}}{3.352 \times 10^4 \times \left[0.5 \times \rho \times \pi \times \left(\Phi_{rock}/2 \right)^3 \times \left[\min\left(\sqrt{\left(2 \times 9.81 \times \left(F_{ih} + \left(250/\cos(slope^{o}) \right) \right) (\tan(slope)) - 0.6 \right)}; 0.8 \times slope^{o} \right)^2 ; 0.64 \times slope^{o} \right] + 0.25 \times \rho \times \pi \left(\Phi \cdots \right. \right.}$$

$$RPH = \max(0.01; 1 - B)$$

$$RPI = 1 - \max(0.01; 1\text{-}B)$$

For the two equations, an *RPI* of 99% expresses the fact that the protection is very efficient (99% of the rocks are stopped).

5.1.3 Adaptation to landscape scale

Two different approaches can be considered for the assessment of protection against rockfall at the landscape scale (representative landscapes or virtual landscapes).

The first one consists simply in reproducing the analysis done at the RST scale at the landscape scale. In this case, the result is a map with an index of the RPI calculated for each polygon (stand). The distribution of these *RPI* values (e.g. weighted percentiles) can be used to characterize the protection function at the landscape scale. However, such an approach does not take into account propagation phenomena and thus is poorly connected to the real protection efficiency of slopes. **The indices at the landscape scale are the 10%, 50% and 90% weighted percentiles of RPI values: $RPI_{10\%}$, $RPI_{50\%}$, $RPI_{90\%}$**

The second approach aims to use spatially explicit information of stand polygons along the slope. Such an approach needs first to define the parts of the landscape with a forested slope inferior to 250 m, for which protection efficiency equals 0. Secondly, it needs to use forest parameters along the remaining slopes, starting from the release area to the border of the forest downslope. The globalisation consists then in calculating the mean values of DBH, slope angle and other parameters and to apply equations *A* or *B* at the slope level. In this case, the value of 250 m needs to be replaced by the total slope length considered for the slope.

In the second approach, the indices at the landscape scale are the same as the first option but with RPI values computed at the slope scale: $RPI_{10\%}$, $RPI_{50\%}$, $RPI_{90\%}$.

5.1.4 Discussion

The justification to use this RPI instead the one initially proposed by the colleagues of ETHZ is that this index is independent of the concept of the optimal stand in terms of stability but based on the value of the dendrometric parameters needed for having a PRH of 1% (as the risk 0 does not exist we have fixed the minimal value of the PRH to 1%). The PRI proposed is then an instantaneous index that does not take into account the distance to an optimal stand in term of stability.

To use the *RPI*, the forest slope length has been set to 250 m.. Some input data could possibly be adapted to the specific conditions of the CSAs, including rock volume, rock density, etc.

5.1.5 Key references

Berger, F., Dorren, L. 2007. Principle of the tool Rockfor.net for quantifying the rockfall hazard below a protection forest. Schweiz Z Forstwes 158(6): 157-165

Berger, F., et al. 2004. Final report of the European project ROCKFOR, 4Th PCRD, Cemagref 300 pp.

Cerbum G. et al. 2013. Management strategies to adapt Alpine space forests to climate change risk, ed. InTech, in press

Dorren, L., Berger, F. 2006. Stem breakage of trees and energy dissipation during rockfall impacts. Tree Physiology 26: 63 – 71.

Dorren, L.K.A., Berger, F., Putters, U.S. 2005. Real size experiments and 3D simulation of rockfall on forested and non-forested slopes. Natural Hazards and Earth System Sciences 6: 145-153

Dorren, L.K.A., Berger, F., Jonnson, M., Krautblatter, M., Moelk, M., Stoffel, M., Wehrli, A. 2007. State of the art in rockfall - forest interactions. Schweizerische Zeitschrift für Forstwesen 158(6): 128-141.

Dorren, L., Berger, F., Métral, R. 2005. Der optimale Schutzwald gegen Steinschlag. Wald und Holz, vol. 11, p. 2 - 4 [ ]

Gauquelin, X., Courbaud, B. (eds.). 2006. Guide des sylvicultures de montagne des Alpes du Nord Françaises. 154 p.

Frehner, M., Wasser, B., Schwitter, R. 2005. Nachhaltigkeit und Erfolgskontrolle im Schutzwald. Wegleitung für Pflegemassnahmen in Wäldern mit Schutzfunktion. © OFEV,Berne,2005

5.2 Protection against avalanches

5.2.1 Definition & justification

Forests are effective against snow avalanches only in the release zones. The efficiency of the protection offered by a forest stand depends on:

- The mean tree height, which has to be at least equal to twice the maximum snow height.
- The value of canopy cover in winter. This variable impacts snow interception, its deposition on the soil, and the quality (heterogeneity) of the snow cover.
- The stand dendrometric parameters: stem density, basal area, and mean DBH. The above variables have a positive effect on the mechanical anchorage of the snow cover.
- The slope.
- The roughness of the forest floor.
- The size of gaps in the stand: they should not exceed 1.5 times mean tree height in the direct slope line.

The effect of the snow interception on the snow cover stabilization represents 70% of the protection provided by a forest stand. The mechanical anchorage represents 30% of the protection effect of a forest stand (Berger, 1997).

As for rockfalls, it is possible to calculate for a given stand an **avalanche protection index (*API*)** based on the ratio between the current stand parameters and the ones needed for an instantaneous optimal protection.

For calculating the *API* the main assumption is that for a given mean DBH the basal area is the dendrometric parameter that can be used to synthesize both the interception and the mechanical effects. Knowing the basal area needed to avoid a snow avalanche release, it is possible to calculate the *API* via the ratio (current stand basal area / basal area needed).

5.2.2 Description

The input data for the calculation of the *API* for one pixel located on a snow avalanche release zone (slope of the pixel between 28 and 55° and an elevation superior to 800m) are given in table 10.

Table 10: input data for the calculation of the *API* for one pixel

Forest stand			Topography		
Name	Abbreviation	Units	Name	Abbreviation	Units
Basal area	G	m²/ha	Slope value	$slope°$	degree
Average Diameter at breast Height	$\overline{DBH}$	cm			

Actually, the value of API depends on the size of gaps in the stand (API equals 0 when gap size exceeds 1.5*mean Tree Height). As most models are not spatially explicit regarding tree coordinates, we decided to skip this parameter.

<u>**For pure evergreen stands**</u> then the formula for calculating the *API* is:

$$API = \min\left[\frac{G}{(0.2901 * \overline{DBH} + 1.494) \times (0.1333 * slope° - 3)}; 1\right]$$

<u>**For mixed and pure deciduous (including larch) forests (less than 70% of evergreen stems)**</u> the formula for calculating the *API* is:

$$API = \min\left[\frac{G}{(0.528 * \overline{DBH} + 1.5566) \times (0.1333 * slope° - 3)}; 1\right]$$

An API of 1 expresses the fact that the protection is very efficient.

5.2.3 Adaptation to landscape scale

Adaptation to landscape scale necessitates identifying release zones (slope between 28 and 55° with an elevation above see level superior to 800m) in the landscape. API will be calculated only on these forested release zones (we can use both polygon scale or release zone scale).

At the landscape scale the 10%, 50% and 90% weighted percentile of *API* values: $API_{10\%}$, $API_{50\%}$, $API_{90\%}$ should be used.

5.2.4 Discussion

For automatic/semi-automated detection of potential release areas in canopy gaps the difference between the digital surface model (DSM) and digital terrain model (DTM) acquired by airborne laser scanning (ALS) can be used. High precision test data have been collected for a test site in the Montafon valley. In many regions ALS data can be acquired as standard data. Several GIS products offer processing tools that help to identify and describe canopy gaps detected from ALS data.

5.2.5 Key references

Berger, F. 1997. Interaction forêt de montagne-risques naturels. Détermination de Zones d'Interventions Forestières Prioritaires – L'exemple du département de la Savoie, thèse de doctorat, Paris, Engref, 475 p.

Berger, F., Lievois, J. 1999. Determination of priority forest work areas and creation of green areas in risk prevention plans - an example of researcher-specialist transfer. Proceedings of the International Conference on Mountain Natural Hazards, April 12-14, 1999. Grenoble, France.

Berger F., Mermin, E. 1999. Modelling of forest cover influence on snow distribution, Colloque Structure of mountain forest sept 6-10-1999 IUFRO davos CH

Gauquelin, X., Courbaud, B. (ed.) 2006. Guide des sylvicultures de montagne des Alpes du Nord Françaises. 154 p. [2114 (GR). 06/0019 (DG).]

Frehner, M., Wasser B., Schwitter, R. 2005. Nachhaltigkeit und Erfolgskontrolle im Schutzwald. Wegleitung für Pflegemassnahmen in Wäldern mit Schutzfunktion. © OFEV, Berne.

5.3 Protection against landslides and erosion

5.3.1 Definition & justification

For this category of phenomena and before the results coming from modeling works using landslide models able to take into account the role played by stands, we propose to use simple recommendations provided by NaiS (Frehner et al. 2005) and french GSM (Gauquelin & Courbaud 2006).

5.3.2 Description

Forests can reduce the likelihood and extent of landslides or erosion by mechanically reinforcing the soil through its rooting system, and can positively influence the water balance in the soil through interception, transpiration and enhanced soil permeability (Frehner et al. 2005). Well-developed forests that are multi-layered provide the greatest protection from both landslides and erosion. The assumption being that a well-structured above ground forest will have a corresponding well-structured and extensive rooting system that will minimize landslide potential.

Guidelines suggest that in areas where landslides may originate that the minimum profile is a forest that is multi-layered and has canopy coverage ≥ 30%-40% canopy coverage. The ideal profile is a multi-layered forest with ≥ 60% canopy coverage.

We calculated our **Landslide Protection Index (*LPI*)** by using forest cover (% projected canopy cover area: cannot be superior to 100% ; all trees with a dbh ≥ 5cm) only as clear thresholds for stand stratification are not available:

- Forest cover < 30% : LPI=low

- Forest cover ≥ 30% and <60% : LPI=medium

- Forest cover ≥ 60% : LPI=high

5.3.3 Adaptation to the landscape scale

LPI can be calculated for each stand polygon in the landscape. The indices at the landcsape scales are the percentage of area of the landscape per LPI class: LPI_{low}, LPI_{medium}, LPI_{high},

5.3.4 Discussion

The index is only relevant for superficial landslides.

5.3.5 Key references

Frehner, M., Wasser B., Schwitter, R. 2005. Nachhaltigkeit und Erfolgskontrolle im Schutzwald. Wegleitung für Pflegemassnahmen in Wäldern mit Schutzfunktion. © OFEV,Berne,2005

Gauquelin, X., Courbaud, B. (ed.) 2006. Guide des sylvicultures de montagne des Alpes du Nord Françaises. 154 p. [2114 (GR). 06/0019 (DG).]

6 Game Management

6.1 Definition and justification

Game species populations and hunting has increased dramatically throughout Europe over the last century often over sustainable levels. Effects of hunting extend far beyond the game species and are not always positive. Often, the presence of hunting species in natural environments negatively affects other flora and wildlife. The main conflicts detected with game species are overbrowsing, crop damages, traffic accidents, and diseases transmission. However, hunting also promote rural development, since it provides direct revenues and labour and contributes to maintain cultural heritage, nature diversity and knowledge, among other benefits. Therefore, we believe that ARANGE project, which is focused on a multifunctional approach, should not ignore hunting and hunting species when considering forest use in European high mountain ecosystems. The main objective with this delivery is to make possible to consider hunting ecosystem services in the multi-criteria models developed in ARANGE. To do so, we have detected two possible approaches:

1) Get a game management scenario in every case study: get a full description of the hunting ecosystem services in the different case studies so we can get a realistic image of game management and hunting-silvicultural conflicts. This information, coming from questionnaires, could be the starting point to develop possible future scenarios in the modelling. Data available consist of net revenues of hunting management and information about silvicultural-games species conflict measured in terms of quantity of browsing.
2) Linker functions to qualitatively relate hunting, forest and game-forest management conflicts are provided.

6.2 Game management scenario in every case study

In order to measure the economic and social importance of hunting ecosystems services in each case study area we have collected information about local fauna population and their management (how raising and harvesting activities are organized and marketed, and a measurement of the current hunting-forest conflict) through a questionnaire (Appendix 2).

6.3 Game management-forest conflict linker functions

In this section we present indicators to describe game management-forest conflicts. Indicators are selected either from the literature (Putman, 1996; Bergquist et al. 1998; Dumon et al. 2005; Fernández-Olalla et al. 2006; Moser et al. 2006; Pépin et al. 2006; Storms et al. 2006; Ward et al. 2008; Reimoser et al. 2009; Nopp-Mayr et al. 2011; Borkowski et al. 2012; Gerhardt et al. 2013) or from the questionnaires addressed by the hunting managers in every case study (Appendix 2, 3). Although indicators presented here (Table 11) are measurable in every CSA, we are not able to define the thresholds for each indicator since they might change among CSA and interact meaningfully with deer abundance. Therefore, we are only able to define the general direction of the correlations between indicators and browsing (qualitative-threshold, Table 11). The unique quantitative-threshold defined in this delivery is deer abundance (Table 12), and it has particular values for every case study area.

Indicators to address main game-forest conflict (browsing) at landscape scale are:

- ✓ Non tree-forest surface: There is evidence that forage availability, in terms of quality, quantity and distribution, determine deer impact on forest (Putman, 1996; Bergquist et al. 1998; Borkowski et al. 2012, Ward et al. 2008). Higher forage availability (more quantity, better quality, seasonally balanced food, and extended distribution) means that the browsing pressure in forest can be lessened. We use non tree-forest surface as a proxy of grass and shrubs availability in a tree-forest context, although there are other factors influencing deer impact (temporal and space distribution, for example). We hypothesis that medium forest cover-range at landscape scale is the most favourable habitat structure for deer because this situation provide the best food availability (good cover of herb- and shrub-layer) and enough sheltering. Too dense forest cover-range is suboptimal for food availability (Moser et al. 2006; Reimoser et al. 2009; Nopp-Mayr et al. 2011). Too open forest cover-range conditions are good for forage availability but can be suboptimal for shelter and trees because they could be overbrowsed as deer impact is more concentrate.

- ✓ Tree species: Some tree species are preferred by deer and would therefore naturally suffer from more severe impact (Fernández-Olalla et al. 2006; Pépin et al. 2006; Ward et al. 2008). Tree selection is commonly related to nutrient contents (Dumon et al. 2005; Pépin et al. 2006; Ward et al. 2008). However, there are other tree properties that influence deer impact such as height, diameter at breast height, tree vitality, wood density, etc. (Bergquist et al. 1998; Nopp-Mayr et al. 2011). These other properties go beyond current objective. Every case study has its own preferable trees.
- ✓ Regeneration area size and regeneration density: Higher regeneration area size and density allocate deer impact to a higher surface and larger number of plants, therefore regeneration is less vulnerable (Storms et al. 2006; Reimoser et al. 2009).
- ✓ Management regime close to nature: Forest ecosystems closer to natural condition provide higher plant diversity so the impact of deer on regeneration should be smaller. Also, management regimes closer to nature should provide a more complex forest structure which would provide more shelter to deer (in terms of hiding and thermal cover, Storms et al. 2006; Reimoser et al. 2009; Nopp-Mayr et al. 2011). Thus management regimes closer to nature are more favourable to deer habitat and decrease deer impact on forest.
- ✓ Deer abundance: Higher deer densities contribute to higher deer impact on forest (Fernández-Olalla et al. 2006; Pépin et al. 2006; Ward et al. 2008; Nopp-Mayr et al. 2011). In Table 12 we show quantitatively the deer abundance-browsing threshold defined for every case study.

Table 11. Factors that influence deer browsing following Gerhardt et al. (2013).

Factors	Correlation with browsing
Non tree-forest surface	-
Tree species (select species)	+
Regeneration area size and density	-
Management regime (close to nature)	-
Deer abundance	+

Table 12. Current silvicultural-game conflict scenario and threshold deer abundance in every case study (NA: Not available; an/100ha: animal/100ha)

Case study	S (ha)	Game species producing silvicultural conflicts	Current density of game population (an/100ha)	Current level of forest damages (% regeneration lost)	Silvicultural-game conflict threshold density (an/100ha)		
					May not negatively influence forest	The forest conflict starts	The forest conflict is severe
Dinaric Mountains (Slovenia)	5000	Roe deer & Red deer	11.5	52,6	NA	NA	NA
Valsaín (Spain)	10668	Roe deer	3.6	0	3.6	9	NA
Vilhelmina (Sweden)	300000	Moose					
National Forest Centre Zvolen (Slovakia)	CS1: 3769	Roe deer	3.5	60	3	4	5
	CS2: 4153		4.0	35	2	3	4
	CS3: 3401		3.0	35	2	3	4
	CS4: 5451		NA	NA	NA	NA	NA
	Pondered average		3.5	42	2	3	4
Vercors Massif (France)	CS1: 6700	Roe deer & Red deer	3.9	49			
	CS2: 3300		4.6	78			
	Pondered average		4.2	70	1	3	5

In the case of Spain, fieldwork was carried out to define a relationship between stand-forest characteristics and pasture (in terms of quantity and quality of the pasture). So an ulterior game species habitat characterization which takes into account diet sources could be defined at the stand level (see Appendix 4). The formula resulted was:

$$\text{Grass cover } (\%) = 50{,}09804 - 0{,}1909 \bullet N$$

with N = number of trees per hectare (R^2 = 0,135, and adjusted R^2 = 0,120). In general, more grass cover in a tree forest context meant better habitat quality for roe deer. However, we have found that this was not the main limitation of game species populations in the Spanish case study.

6.4 Adaptation to the landscape scale

The relevant scale of hunting linker functions is landscape, since the animals move from one stand to another easily.

6.5 Key references

Bergquist, J., Örlander, G., 1998. Browsing damage by roe deer on Norway spruce seedlings planted on clearcuts of different ages: 1. Effect of slash removal, vegetation development, and roe deer density. For. Ecol. Manage. 105, 283–293.

Borkowski, J., Ukalski, K., 2012. Bark stripping by red deer in a post-disturbance area: the importance of security cover. Forest Ecology and Management 263 : 17–23.

7 Conclusions

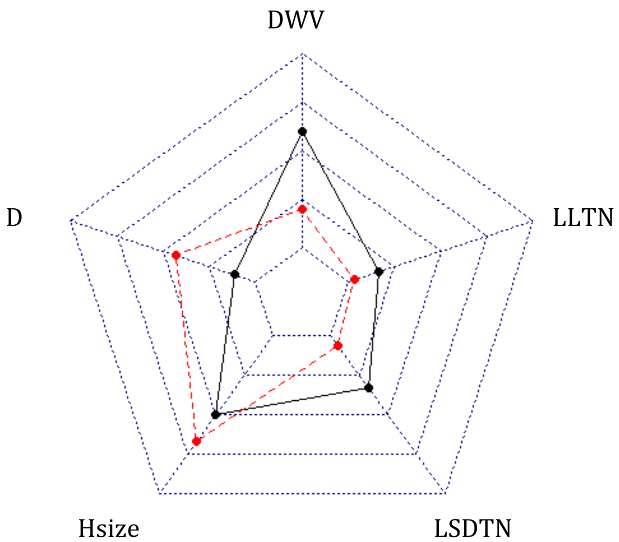
Table 11 provides a synthesis of indices that will be used in the ARANGE project to assess ecosystem services in all CSAs.

Table 11: synthesis of indices used in the ARANGE project

ES	INDICATOR (STAND SCALE)	LANDSCAPE SCALE	CASE-STUDIES COMPARISONS
Production	***TVH*** ($m^3ha^{-1}year^{-1}$) $\boldsymbol{TVH_{species,DBH}}$ ($m^3ha^{-1}year^{-1}$) ***VI*** ($m^3ha^{-1}year^{-1}$) ***V*** (m^3ha^{-1})	For all indices, stand values can be added up per stand type, per management type or for the whole landscape (additive property).	Absolute comparisons ar possible. Maximum values or hig level percentiles (ex. 90%) can b used to standardized values at th case study level for cross cas studies comparisons.
Carbon storage	$\boldsymbol{C_{above}}$ $\boldsymbol{C_{below}}$ $\boldsymbol{C_{soil}}$	For all indices, stand values can be added up per stand type, per management type or for the whole landscape (additive property).	Absolute comparisons ar possible. Maximum values or hig level percentiles (ex. 90%) can b used to standardize values at th case study level for cross cas studies comparisons.
Biodiversity	***D*** $\boldsymbol{H_{size}}$ ***DWV*** **(m^3ha^{-1})** ***LSDTN*** **(ha^{-1})** ***LLTN*** **(ha^{-1})** ***Birds habitat quality score***	D_α, D_β, D_γ; $D_{10\%}$, $D_{50\%}$, $D_{90\%}$ $H_{size,\alpha}$, $H_{size,\beta}$, $H_{size,\gamma}$ $H_{size,10\%}$, $H_{size,50\%}$, $H_{size,90\%}$ $DWV_{10\%}$, $DWV_{50\%}$, $DWV_{90\%}$. A_X $LSDTN_{10\%}$, $LSDTN_{50\%}$, $LSDTN_{90\%}$ A_X $LLTN_{10\%}$, $LLTN_{50\%}$, $LLTN_{90\%}$ A_X *Birds habitat quality score*	Absolute comparisons ar possible. Maximum values or hig level percentiles (ex. 90%) can b used to standardized values at th case study level for cross cas studies comparisons.
Protection against natural hazards	***RPI*** ***API*** ***LPI (%)***	$RPI_{10\%}$, $RPI_{50\%}$, $RPI_{90\%}$ $API_{10\%}$, $API_{50\%}$, $API_{90\%}$ LPI_{low}, LPI_{medium}, LPI_{high}	Absolute comparisons ar relevant.

For each management scenario (landscape of stand level), we need to find a simple way to briefly synthesize its performance according to the different ecosystem services investigated in the ARANGE project. We suggest thus to use radar charts (or star plots), knowing that this kind of charts is poorly suited for analysing trade-off decisions (see WP5). The radarchart function (library « fmsb ») in the R software can be used. It works with dataframe (indices are in columns and scenarios in lines). The first line gives the maximum values of indices and the second lines the minimum values of indices.

Here is an example that illustrates the use of the radarchart function. For the biodiversity ecosystem services, we have 5 indices (except bird habitat quality scores). For one stand we can imagine a first scenario with no management where the abundance of dead wood is high (e.g. $60m^3ha^{-1}$), the numbers of large living and dead tree is high (5 ha^{-1}, 10 ha^{-1}), the diversity of tree size is medium (1.5) and species diversity is quite low (1.8). Another scenario could be based on a silviculture which aim is to trigger stand heterogeneity: abundance of dead wood is medium (e.g. $20m^3ha^{-1}$), the numbers of large dead and living trees are low (2 ha^{-1}, 1 ha^{-1}), diversity of tree sizes and species diversity are quite high (2, 4). Here are the radar charts of these two scenarios (scenario 1 in black, scenario 1 in red):



Appendix 1

Single tree assortment tables

Definition

The attached appendix tables provide single tree assortment tables for *Fagus sylvatica, Picea abies, Pinus sylvestris, Larix decidua, and Abies alba* respectively. The assortment tables are taken from Austrian timber trade-practices and are based on assortment equations defined by Sterba et al. (1986) and Sterba and Griess (1983).

Description (unit, equations)

Assortment table column description

Column name	Description [units]	Notes
BHD	Breast height diameter [cm]	Stem diameter with bark at 1.3 m height above ground.
H/D	Height-diameter ratio	H/D = tree height[m]/BHD[cm]*100
K%	Crown ratio	K% = 1 - *hlc*[m] / tree height[m] Where *hlc* is the height to the live crown from the base (i.e. height above ground to the first green branch). K% is only needed for *Fagus sylvatica* assessments.
efm(D) o.R.	Harvestable volume of coarse wood without bark [m^3]	Harvestable volume in m^3 of coarse wood that has a diameter > 7cm without bark.
SKG	Identification of stem wood (S), crown wood (K), or total coarse wood (G) (sum of S and K)	Total coarse wood is the sum of stem wood and crown wood (G = S + K)

Assortment ID	Description
kapp.	Wood not mentioned in s.NH., 1b, 2a, 2b, 3a, 3b or 4+. The last piece of stem starting from the thinner end of the last log and ending when the diameter reaches 7 cm.
s.NH.	Logs with a diameter of < 15 cm (without bark) at their thinner end; 1, 4, 5 or 6 m long.
1b	Log wood according to "Österreichische Holzhandelsusancen" (ÖHHU) with middle diameter (measured in the middle of the log) of 15 to <20 cm.
2a	Log wood according to ÖHHU with middle diameter of 20 to <25 cm.
3a	Log wood according to ÖHHU with middle diameter of 20 to <25 cm.
3b	Log wood according to ÖHHU with middle diameter of 20 to <25 cm.
4+	Log wood according to ÖHHU with middle diameter of 40 and more cm.

Assortment ID	Description
%D	Proportion of harvestable volume of coarse wood without bark (efm(D) o.R. from table) from the standing volume of coarse wood with bark that has a diameter > 7 cm. %D = harvestable volume [m^3] / standing volume of coarse wood [m^3]
%S	Proportion of harvestable volume of coarse wood without bark (efm(D) o.R. from table) from the standing stem volume with bark that has a diameter > 7 cm. % S = harvestable volume [m^3] / standing stem volume [m^3]

References

For Silver fir, European. larch, Scott pine and European beech:

Sterba, H., Kleine, M., Eckmüllner, O. 1986. Sortentafeln für Tanne, Lärche, Kiefer und Buche. Österreichischer Agrarverlag, Wien. 182 p. ISBN: 3-7040-0851-6

For Norway spruce:

Sterba, H., Griess, O. 1983. Sortentafeln für Fichte. Österreichischer Agrarverlag, Wien.161 p. ISBN: 3-7040-0766-8

Appendix 1.2 *Fagus sylvatica*, single tree assortment tables

BHD	H/D	K%	SKG	kapp.	s.NH.	1b	2a	2b	3a	3b	4+	%D
10	100	30	S	0.002	0.019	0	0	0	0	0	0	-1
10	100	30	K	0	0	0	0	0	0	0	0	-1
10	100	30	G	0.002	0.019	0	0	0	0	0	0	67
10	100	50	S	0.002	0.018	0	0	0	0	0	0	-1
10	100	50	K	0.001	0	0	0	0	0	0	0	-1
10	100	50	G	0.003	0.018	0	0	0	0	0	0	70
10	100	70	S	0.002	0.016	0	0	0	0	0	0	-1
10	100	70	K	0.001	0.001	0	0	0	0	0	0	-1
10	100	70	G	0.003	0.017	0	0	0	0	0	0	69
10	120	30	S	0.002	0.022	0	0	0	0	0	0	-1
10	120	30	K	0	0	0	0	0	0	0	0	-1
10	120	30	G	0.002	0.022	0	0	0	0	0	0	64
10	120	50	S	0.002	0.021	0	0	0	0	0	0	-1
10	120	50	K	0	0	0	0	0	0	0	0	-1
10	120	50	G	0.002	0.021	0	0	0	0	0	0	64
10	120	70	S	0.002	0.019	0	0	0	0	0	0	-1
10	120	70	K	0	0.001	0	0	0	0	0	0	-1
10	120	70	G	0.002	0.02	0	0	0	0	0	0	64
10	140	30	S	0.003	0.026	0	0	0	0	0	0	-1
10	140	30	K	0	0	0	0	0	0	0	0	-1
10	140	30	G	0.003	0.026	0	0	0	0	0	0	66
10	140	50	S	0.003	0.025	0	0	0	0	0	0	-1
10	140	50	K	0	0	0	0	0	0	0	0	-1
10	140	50	G	0.003	0.025	0	0	0	0	0	0	66
10	140	70	S	0.003	0.023	0	0	0	0	0	0	-1
10	140	70	K	0	0	0	0	0	0	0	0	-1
10	140	70	G	0.003	0.023	0	0	0	0	0	0	64
11	100	30	S	0.001	0.03	0	0	0	0	0	0	-1
11	100	30	K	0.001	0	0	0	0	0	0	0	-1
11	100	30	G	0.002	0.03	0	0	0	0	0	0	72
11	100	50	S	0.001	0.029	0	0	0	0	0	0	-1
11	100	50	K	0.001	0	0	0	0	0	0	0	-1
11	100	50	G	0.002	0.029	0	0	0	0	0	0	72
11	100	70	S	0.001	0.025	0	0	0	0	0	0	-1
11	100	70	K	0.001	0.003	0	0	0	0	0	0	-1
11	100	70	G	0.002	0.028	0	0	0	0	0	0	73
11	120	30	S	0.002	0.035	0	0	0	0	0	0	-1
11	120	30	K	0	0	0	0	0	0	0	0	-1
11	120	30	G	0.002	0.035	0	0	0	0	0	0	70
11	120	50	S	0.002	0.034	0	0	0	0	0	0	-1
11	120	50	K	0.001	0	0	0	0	0	0	0	-1
11	120	50	G	0.003	0.034	0	0	0	0	0	0	72
11	120	70	S	0.002	0.03	0	0	0	0	0	0	-1
11	120	70	K	0.001	0.002	0	0	0	0	0	0	-1
11	120	70	G	0.003	0.032	0	0	0	0	0	0	71
11	140	30	S	0.002	0.041	0	0	0	0	0	0	-1
11	140	30	K	0	0	0	0	0	0	0	0	-1
11	140	30	G	0.002	0.041	0	0	0	0	0	0	69
11	140	50	S	0.002	0.039	0	0	0	0	0	0	-1

BHD	H/D	K%	SKG	kapp.	s.NH.	1b	2a	2b	3a	3b	4+	%D
11	140	50	K	0	0	0	0	0	0	0	0	-1
11	140	50	G	0.002	0.039	0	0	0	0	0	0	68
11	140	70	S	0.002	0.035	0	0	0	0	0	0	-1
11	140	70	K	0.001	0.002	0	0	0	0	0	0	-1
11	140	70	G	0.003	0.037	0	0	0	0	0	0	69
12	80	30	S	0	0.036	0	0	0	0	0	0	-1
12	80	30	K	0.001	0	0	0	0	0	0	0	-1
12	80	30	G	0.001	0.036	0	0	0	0	0	0	77
12	80	50	S	0	0.033	0	0	0	0	0	0	-1
12	80	50	K	0.001	0.002	0	0	0	0	0	0	-1
12	80	50	G	0.001	0.035	0	0	0	0	0	0	77
12	80	70	S	0	0.028	0	0	0	0	0	0	-1
12	80	70	K	0.001	0.005	0	0	0	0	0	0	-1
12	80	70	G	0.001	0.033	0	0	0	0	0	0	76
12	100	30	S	0	0.044	0	0	0	0	0	0	-1
12	100	30	K	0.001	0	0	0	0	0	0	0	-1
12	100	30	G	0.001	0.044	0	0	0	0	0	0	75
12	100	50	S	0	0.04	0	0	0	0	0	0	-1
12	100	50	K	0.001	0.003	0	0	0	0	0	0	-1
12	100	50	G	0.001	0.043	0	0	0	0	0	0	76
12	100	70	S	0	0.034	0	0	0	0	0	0	-1
12	100	70	K	0.001	0.006	0	0	0	0	0	0	-1
12	100	70	G	0.001	0.04	0	0	0	0	0	0	73
12	120	30	S	0.001	0.051	0	0	0	0	0	0	-1
12	120	30	K	0.001	0	0	0	0	0	0	0	-1
12	120	30	G	0.002	0.051	0	0	0	0	0	0	74
12	120	50	S	0.001	0.047	0	0	0	0	0	0	-1
12	120	50	K	0.001	0.002	0	0	0	0	0	0	-1
12	120	50	G	0.002	0.049	0	0	0	0	0	0	73
12	120	70	S	0.001	0.04	0	0	0	0	0	0	-1
12	120	70	K	0.001	0.007	0	0	0	0	0	0	-1
12	120	70	G	0.002	0.047	0	0	0	0	0	0	73
12	140	30	S	0.002	0.059	0	0	0	0	0	0	-1
12	140	30	K	0	0	0	0	0	0	0	0	-1
12	140	30	G	0.002	0.059	0	0	0	0	0	0	73
12	140	50	S	0.002	0.055	0	0	0	0	0	0	-1
12	140	50	K	0.001	0.002	0	0	0	0	0	0	-1
12	140	50	G	0.003	0.057	0	0	0	0	0	0	74
12	140	70	S	0.002	0.047	0	0	0	0	0	0	-1
12	140	70	K	0.001	0.007	0	0	0	0	0	0	-1
12	140	70	G	0.003	0.054	0	0	0	0	0	0	73
13	80	30	S	0	0.047	0	0	0	0	0	0	-1
13	80	30	K	0.001	0.001	0	0	0	0	0	0	-1
13	80	30	G	0.001	0.048	0	0	0	0	0	0	78
13	80	50	S	0	0.041	0	0	0	0	0	0	-1
13	80	50	K	0.002	0.005	0	0	0	0	0	0	-1
13	80	50	G	0.002	0.046	0	0	0	0	0	0	79
13	80	70	S	0	0.035	0	0	0	0	0	0	-1
13	80	70	K	0.002	0.009	0	0	0	0	0	0	-1
13	80	70	G	0.002	0.044	0	0	0	0	0	0	79
13	100	30	S	0	0.057	0	0	0	0	0	0	-1

BHD	H/D	K%	SKG	kapp.	s.NH.	1b	2a	2b	3a	3b	4+	%D
13	100	30	K	0.001	0.001	0	0	0	0	0	0	-1
13	100	30	G	0.001	0.058	0	0	0	0	0	0	75
13	100	50	S	0	0.05	0	0	0	0	0	0	-1
13	100	50	K	0.001	0.007	0	0	0	0	0	0	-1
13	100	50	G	0.001	0.057	0	0	0	0	0	0	76
13	100	70	S	0	0.042	0	0	0	0	0	0	-1
13	100	70	K	0.001	0.011	0	0	0	0	0	0	-1
13	100	70	G	0.001	0.053	0	0	0	0	0	0	74
13	120	30	S	0	0.068	0	0	0	0	0	0	-1
13	120	30	K	0.001	0.002	0	0	0	0	0	0	-1
13	120	30	G	0.001	0.07	0	0	0	0	0	0	76
13	120	50	S	0	0.06	0	0	0	0	0	0	-1
13	120	50	K	0.001	0.008	0	0	0	0	0	0	-1
13	120	50	G	0.001	0.068	0	0	0	0	0	0	75
13	120	70	S	0	0.05	0	0	0	0	0	0	-1
13	120	70	K	0.001	0.014	0	0	0	0	0	0	-1
13	120	70	G	0.001	0.064	0	0	0	0	0	0	74
13	140	30	S	0.001	0.078	0	0	0	0	0	0	-1
13	140	30	K	0.001	0.002	0	0	0	0	0	0	-1
13	140	30	G	0.002	0.08	0	0	0	0	0	0	75
13	140	50	S	0.001	0.069	0	0	0	0	0	0	-1
13	140	50	K	0.001	0.009	0	0	0	0	0	0	-1
13	140	50	G	0.002	0.078	0	0	0	0	0	0	75
13	140	70	S	0.001	0.058	0	0	0	0	0	0	-1
13	140	70	K	0.001	0.015	0	0	0	0	0	0	-1
13	140	70	G	0.002	0.073	0	0	0	0	0	0	73
14	80	30	S	0	0.059	0	0	0	0	0	0	-1
14	80	30	K	0.002	0.002	0	0	0	0	0	0	-1
14	80	30	G	0.002	0.061	0	0	0	0	0	0	79
14	80	50	S	0	0.052	0	0	0	0	0	0	-1
14	80	50	K	0.002	0.007	0	0	0	0	0	0	-1
14	80	50	G	0.002	0.059	0	0	0	0	0	0	79
14	80	70	S	0	0.044	0	0	0	0	0	0	-1
14	80	70	K	0.002	0.013	0	0	0	0	0	0	-1
14	80	70	G	0.002	0.057	0	0	0	0	0	0	79
14	100	30	S	0	0.073	0	0	0	0	0	0	-1
14	100	30	K	0.001	0.002	0	0	0	0	0	0	-1
14	100	30	G	0.001	0.075	0	0	0	0	0	0	76
14	100	50	S	0	0.064	0	0	0	0	0	0	-1
14	100	50	K	0.001	0.009	0	0	0	0	0	0	-1
14	100	50	G	0.001	0.073	0	0	0	0	0	0	76
14	100	70	S	0	0.054	0	0	0	0	0	0	-1
14	100	70	K	0.002	0.016	0	0	0	0	0	0	-1
14	100	70	G	0.002	0.07	0	0	0	0	0	0	77
14	120	30	S	0	0.088	0	0	0	0	0	0	-1
14	120	30	K	0.001	0.003	0	0	0	0	0	0	-1
14	120	30	G	0.001	0.091	0	0	0	0	0	0	77
14	120	50	S	0	0.077	0	0	0	0	0	0	-1
14	120	50	K	0.001	0.011	0	0	0	0	0	0	-1
14	120	50	G	0.001	0.088	0	0	0	0	0	0	77
14	120	70	S	0	0.065	0	0	0	0	0	0	-1

BHD	H/D	K%	SKG	kapp.	s.NH.	1b	2a	2b	3a	3b	4+	%D
14	120	70	K	0.002	0.019	0	0	0	0	0	0	-1
14	120	70	G	0.002	0.084	0	0	0	0	0	0	77
14	140	30	S	0.001	0.102	0	0	0	0	0	0	-1
14	140	30	K	0.001	0.003	0	0	0	0	0	0	-1
14	140	30	G	0.002	0.105	0	0	0	0	0	0	77
14	140	50	S	0.001	0.089	0	0	0	0	0	0	-1
14	140	50	K	0.001	0.013	0	0	0	0	0	0	-1
14	140	50	G	0.002	0.102	0	0	0	0	0	0	77
14	140	70	S	0.001	0.075	0	0	0	0	0	0	-1
14	140	70	K	0.002	0.022	0	0	0	0	0	0	-1
14	140	70	G	0.003	0.097	0	0	0	0	0	0	77
15	80	30	S	0	0.074	0	0	0	0	0	0	-1
15	80	30	K	0.002	0.003	0	0	0	0	0	0	-1
15	80	30	G	0.002	0.077	0	0	0	0	0	0	80
15	80	50	S	0	0.065	0	0	0	0	0	0	-1
15	80	50	K	0.002	0.01	0	0	0	0	0	0	-1
15	80	50	G	0.002	0.075	0	0	0	0	0	0	80
15	80	70	S	0	0.054	0	0	0	0	0	0	-1
15	80	70	K	0.002	0.016	0	0	0	0	0	0	-1
15	80	70	G	0.002	0.07	0	0	0	0	0	0	77
15	100	30	S	0	0.092	0	0	0	0	0	0	-1
15	100	30	K	0.001	0.004	0	0	0	0	0	0	-1
15	100	30	G	0.001	0.096	0	0	0	0	0	0	78
15	100	50	S	0	0.08	0	0	0	0	0	0	-1
15	100	50	K	0.002	0.012	0	0	0	0	0	0	-1
15	100	50	G	0.002	0.092	0	0	0	0	0	0	78
15	100	70	S	0	0.068	0	0	0	0	0	0	-1
15	100	70	K	0.002	0.02	0	0	0	0	0	0	-1
15	100	70	G	0.002	0.088	0	0	0	0	0	0	77
15	120	30	S	0	0.111	0	0	0	0	0	0	-1
15	120	30	K	0.001	0.004	0	0	0	0	0	0	-1
15	120	30	G	0.001	0.115	0	0	0	0	0	0	78
15	120	50	S	0	0.097	0	0	0	0	0	0	-1
15	120	50	K	0.001	0.014	0	0	0	0	0	0	-1
15	120	50	G	0.001	0.111	0	0	0	0	0	0	77
15	120	70	S	0	0.082	0	0	0	0	0	0	-1
15	120	70	K	0.002	0.024	0	0	0	0	0	0	-1
15	120	70	G	0.002	0.106	0	0	0	0	0	0	77
15	140	30	S	0.001	0.129	0	0	0	0	0	0	-1
15	140	30	K	0.001	0.005	0	0	0	0	0	0	-1
15	140	30	G	0.002	0.134	0	0	0	0	0	0	78
15	140	50	S	0.001	0.112	0	0	0	0	0	0	-1
15	140	50	K	0.002	0.017	0	0	0	0	0	0	-1
15	140	50	G	0.003	0.129	0	0	0	0	0	0	78
15	140	70	S	0.001	0.095	0	0	0	0	0	0	-1
15	140	70	K	0.002	0.028	0	0	0	0	0	0	-1
15	140	70	G	0.003	0.123	0	0	0	0	0	0	77
16	80	30	S	0	0.072	0.019	0	0	0	0	0	-1
16	80	30	K	0.002	0.004	0	0	0	0	0	0	-1
16	80	30	G	0.002	0.076	0.019	0	0	0	0	0	80
16	80	50	S	0	0.061	0.017	0	0	0	0	0	-1

BHD	H/D	K%	SKG	kapp.	s.NH.	1b	2a	2b	3a	3b	4+	%D
16	80	50	K	0.002	0.012	0.001	0	0	0	0	0	-1
16	80	50	G	0.002	0.073	0.018	0	0	0	0	0	79
16	80	70	S	0	0.05	0.013	0	0	0	0	0	-1
16	80	70	K	0.003	0.021	0.003	0	0	0	0	0	-1
16	80	70	G	0.003	0.071	0.016	0	0	0	0	0	79
16	100	30	S	0	0.087	0.026	0	0	0	0	0	-1
16	100	30	K	0.001	0.005	0	0	0	0	0	0	-1
16	100	30	G	0.001	0.092	0.026	0	0	0	0	0	78
16	100	50	S	0	0.074	0.024	0	0	0	0	0	-1
16	100	50	K	0.002	0.015	0.001	0	0	0	0	0	-1
16	100	50	G	0.002	0.089	0.025	0	0	0	0	0	78
16	100	70	S	0	0.06	0.019	0	0	0	0	0	-1
16	100	70	K	0.002	0.026	0.004	0	0	0	0	0	-1
16	100	70	G	0.002	0.086	0.023	0	0	0	0	0	78
16	120	30	S	0	0.102	0.034	0	0	0	0	0	-1
16	120	30	K	0.001	0.006	0	0	0	0	0	0	-1
16	120	30	G	0.001	0.108	0.034	0	0	0	0	0	78
16	120	50	S	0	0.086	0.032	0	0	0	0	0	-1
16	120	50	K	0.002	0.018	0.001	0	0	0	0	0	-1
16	120	50	G	0.002	0.104	0.033	0	0	0	0	0	78
16	120	70	S	0	0.07	0.026	0	0	0	0	0	-1
16	120	70	K	0.002	0.031	0.005	0	0	0	0	0	-1
16	120	70	G	0.002	0.101	0.031	0	0	0	0	0	78
17	80	30	S	0	0.079	0.031	0	0	0	0	0	-1
17	80	30	K	0.002	0.005	0	0	0	0	0	0	-1
17	80	30	G	0.002	0.084	0.031	0	0	0	0	0	80
17	80	50	S	0	0.066	0.029	0	0	0	0	0	-1
17	80	50	K	0.003	0.015	0.001	0	0	0	0	0	-1
17	80	50	G	0.003	0.081	0.03	0	0	0	0	0	80
17	80	70	S	0	0.053	0.024	0	0	0	0	0	-1
17	80	70	K	0.003	0.025	0.004	0	0	0	0	0	-1
17	80	70	G	0.003	0.078	0.028	0	0	0	0	0	79
17	100	30	S	0	0.095	0.043	0	0	0	0	0	-1
17	100	30	K	0.001	0.007	0	0	0	0	0	0	-1
17	100	30	G	0.001	0.102	0.043	0	0	0	0	0	80
17	100	50	S	0	0.079	0.04	0	0	0	0	0	-1
17	100	50	K	0.002	0.019	0.002	0	0	0	0	0	-1
17	100	50	G	0.002	0.098	0.042	0	0	0	0	0	80
17	100	70	S	0	0.063	0.033	0	0	0	0	0	-1
17	100	70	K	0.003	0.032	0.005	0	0	0	0	0	-1
17	100	70	G	0.003	0.095	0.038	0	0	0	0	0	79
17	120	30	S	0	0.11	0.056	0	0	0	0	0	-1
17	120	30	K	0.001	0.008	0	0	0	0	0	0	-1
17	120	30	G	0.001	0.118	0.056	0	0	0	0	0	80
17	120	50	S	0	0.091	0.052	0	0	0	0	0	-1
17	120	50	K	0.002	0.023	0.002	0	0	0	0	0	-1
17	120	50	G	0.002	0.114	0.054	0	0	0	0	0	79
17	120	70	S	0	0.072	0.044	0	0	0	0	0	-1
17	120	70	K	0.003	0.038	0.007	0	0	0	0	0	-1
17	120	70	G	0.003	0.11	0.051	0	0	0	0	0	79
18	80	30	S	0	0.085	0.047	0	0	0	0	0	-1

BHD	H/D	K%	SKG	kapp.	s.NH.	1b	2a	2b	3a	3b	4+	%D
18	80	30	K	0.002	0.007	0	0	0	0	0	0	-1
18	80	30	G	0.002	0.092	0.047	0	0	0	0	0	81
18	80	50	S	0	0.07	0.044	0	0	0	0	0	-1
18	80	50	K	0.003	0.019	0.001	0	0	0	0	0	-1
18	80	50	G	0.003	0.089	0.045	0	0	0	0	0	80
18	80	70	S	0	0.054	0.039	0	0	0	0	0	-1
18	80	70	K	0.003	0.031	0.003	0	0	0	0	0	-1
18	80	70	G	0.003	0.085	0.042	0	0	0	0	0	79
18	100	30	S	0	0.101	0.064	0	0	0	0	0	-1
18	100	30	K	0.001	0.008	0	0	0	0	0	0	-1
18	100	30	G	0.001	0.109	0.064	0	0	0	0	0	80
18	100	50	S	0	0.082	0.06	0	0	0	0	0	-1
18	100	50	K	0.002	0.023	0.002	0	0	0	0	0	-1
18	100	50	G	0.002	0.105	0.062	0	0	0	0	0	79
18	100	70	S	0	0.064	0.055	0	0	0	0	0	-1
18	100	70	K	0.003	0.038	0.003	0	0	0	0	0	-1
18	100	70	G	0.003	0.102	0.058	0	0	0	0	0	79
18	120	30	S	0	0.116	0.083	0	0	0	0	0	-1
18	120	30	K	0.001	0.01	0	0	0	0	0	0	-1
18	120	30	G	0.001	0.126	0.083	0	0	0	0	0	80
18	120	50	S	0	0.094	0.077	0	0	0	0	0	-1
18	120	50	K	0.002	0.028	0.003	0	0	0	0	0	-1
18	120	50	G	0.002	0.122	0.08	0	0	0	0	0	80
18	120	70	S	0	0.072	0.071	0	0	0	0	0	-1
18	120	70	K	0.003	0.046	0.004	0	0	0	0	0	-1
18	120	70	G	0.003	0.118	0.075	0	0	0	0	0	80
19	80	30	S	0	0.09	0.066	0	0	0	0	0	-1
19	80	30	K	0.002	0.008	0	0	0	0	0	0	-1
19	80	30	G	0.002	0.098	0.066	0	0	0	0	0	80
19	80	50	S	0	0.072	0.062	0	0	0	0	0	-1
19	80	50	K	0.003	0.022	0.002	0	0	0	0	0	-1
19	80	50	G	0.003	0.094	0.064	0	0	0	0	0	80
19	80	70	S	0	0.054	0.056	0	0	0	0	0	-1
19	80	70	K	0.004	0.037	0.004	0	0	0	0	0	-1
19	80	70	G	0.004	0.091	0.06	0	0	0	0	0	80
19	100	30	S	0	0.106	0.09	0	0	0	0	0	-1
19	100	30	K	0.001	0.01	0	0	0	0	0	0	-1
19	100	30	G	0.001	0.116	0.09	0	0	0	0	0	80
19	100	50	S	0	0.084	0.084	0	0	0	0	0	-1
19	100	50	K	0.002	0.028	0.003	0	0	0	0	0	-1
19	100	50	G	0.002	0.112	0.087	0	0	0	0	0	80
19	100	70	S	0	0.062	0.076	0	0	0	0	0	-1
19	100	70	K	0.003	0.046	0.006	0	0	0	0	0	-1
19	100	70	G	0.003	0.108	0.082	0	0	0	0	0	80
19	120	30	S	0	0.12	0.116	0	0	0	0	0	-1
19	120	30	K	0.001	0.012	0	0	0	0	0	0	-1
19	120	30	G	0.001	0.132	0.116	0	0	0	0	0	80
19	120	50	S	0	0.094	0.107	0	0	0	0	0	-1
19	120	50	K	0.002	0.034	0.005	0	0	0	0	0	-1
19	120	50	G	0.002	0.128	0.112	0	0	0	0	0	80
19	120	70	S	0	0.068	0.097	0	0	0	0	0	-1

BHD	H/D	K%	SKG	kapp.	s.NH.	1b	2a	2b	3a	3b	4+	%D
19	120	70	K	0.003	0.055	0.009	0	0	0	0	0	-1
19	120	70	G	0.003	0.123	0.106	0	0	0	0	0	80
20	80	30	S	0	0.093	0.09	0	0	0	0	0	-1
20	80	30	K	0.002	0.01	0	0	0	0	0	0	-1
20	80	30	G	0.002	0.103	0.09	0	0	0	0	0	81
20	80	50	S	0	0.073	0.085	0	0	0	0	0	-1
20	80	50	K	0.003	0.027	0.002	0	0	0	0	0	-1
20	80	50	G	0.003	0.1	0.087	0	0	0	0	0	81
20	80	70	S	0	0.053	0.075	0	0	0	0	0	-1
20	80	70	K	0.004	0.043	0.007	0	0	0	0	0	-1
20	80	70	G	0.004	0.096	0.082	0	0	0	0	0	80
20	100	30	S	0	0.109	0.121	0	0	0	0	0	-1
20	100	30	K	0.001	0.012	0	0	0	0	0	0	-1
20	100	30	G	0.001	0.121	0.121	0	0	0	0	0	80
20	100	50	S	0	0.084	0.113	0	0	0	0	0	-1
20	100	50	K	0.003	0.033	0.004	0	0	0	0	0	-1
20	100	50	G	0.003	0.117	0.117	0	0	0	0	0	81
20	100	70	S	0	0.059	0.1	0	0	0	0	0	-1
20	100	70	K	0.003	0.054	0.011	0	0	0	0	0	-1
20	100	70	G	0.003	0.113	0.111	0	0	0	0	0	80
20	120	30	S	0	0.122	0.156	0	0	0	0	0	-1
20	120	30	K	0.001	0.015	0	0	0	0	0	0	-1
20	120	30	G	0.001	0.137	0.156	0	0	0	0	0	81
20	120	50	S	0	0.092	0.144	0	0	0	0	0	-1
20	120	50	K	0.003	0.04	0.007	0	0	0	0	0	-1
20	120	50	G	0.003	0.132	0.151	0	0	0	0	0	81
20	120	70	S	0	0.062	0.128	0	0	0	0	0	-1
20	120	70	K	0.004	0.065	0.015	0	0	0	0	0	-1
20	120	70	G	0.004	0.127	0.143	0	0	0	0	0	80
21	60	50	S	0	0	0.061	0.076	0	0	0	0	-1
21	60	50	K	0.005	0.023	0.001	0	0	0	0	0	-1
21	60	50	G	0.005	0.023	0.062	0.076	0	0	0	0	81
21	60	70	S	0	0	0.056	0.048	0	0	0	0	-1
21	60	70	K	0.005	0.038	0.005	0.006	0	0	0	0	-1
21	60	70	G	0.005	0.038	0.061	0.054	0	0	0	0	80
21	80	30	S	0	0.096	0.094	0.023	0	0	0	0	-1
21	80	30	K	0.002	0.011	0	0	0	0	0	0	-1
21	80	30	G	0.002	0.107	0.094	0.023	0	0	0	0	80
21	80	50	S	0	0	0.09	0.093	0	0	0	0	-1
21	80	50	K	0.003	0.031	0.003	0	0	0	0	0	-1
21	80	50	G	0.003	0.031	0.093	0.093	0	0	0	0	80
21	80	70	S	0	0	0.083	0.057	0	0	0	0	-1
21	80	70	K	0.004	0.05	0.009	0.008	0	0	0	0	-1
21	80	70	G	0.004	0.05	0.092	0.065	0	0	0	0	80
21	100	30	S	0	0.111	0.125	0.033	0	0	0	0	-1
21	100	30	K	0.001	0.014	0	0	0	0	0	0	-1
21	100	30	G	0.001	0.125	0.125	0.033	0	0	0	0	81
21	100	50	S	0	0	0.12	0.109	0	0	0	0	-1
21	100	50	K	0.003	0.039	0.006	0	0	0	0	0	-1
21	100	50	G	0.003	0.039	0.126	0.109	0	0	0	0	81
21	100	70	S	0	0	0.111	0.064	0	0	0	0	-1

BHD	H/D	K%	SKG	kapp.	s.NH.	1b	2a	2b	3a	3b	4+	%D
21	100	70	K	0.004	0.063	0.013	0.011	0	0	0	0	-1
21	100	70	G	0.004	0.063	0.124	0.075	0	0	0	0	81
21	120	30	S	0	0.122	0.156	0.045	0	0	0	0	-1
21	120	30	K	0.001	0.017	0.001	0	0	0	0	0	-1
21	120	30	G	0.001	0.139	0.157	0.045	0	0	0	0	81
21	120	50	S	0	0	0.15	0.124	0	0	0	0	-1
21	120	50	K	0.003	0.047	0.009	0.001	0	0	0	0	-1
21	120	50	G	0.003	0.047	0.159	0.125	0	0	0	0	81
21	120	70	S	0	0	0.139	0.07	0	0	0	0	-1
21	120	70	K	0.004	0.076	0.018	0.013	0	0	0	0	-1
21	120	70	G	0.004	0.076	0.157	0.083	0	0	0	0	81
22	60	50	S	0	0	0.069	0.088	0	0	0	0	-1
22	60	50	K	0.005	0.027	0.001	0.002	0	0	0	0	-1
22	60	50	G	0.005	0.027	0.07	0.09	0	0	0	0	81
22	60	70	S	0	0	0.064	0.056	0	0	0	0	-1
22	60	70	K	0.006	0.044	0.006	0.009	0	0	0	0	-1
22	60	70	G	0.006	0.044	0.07	0.065	0	0	0	0	81
22	80	30	S	0	0.098	0.106	0.044	0	0	0	0	-1
22	80	30	K	0.002	0.013	0	0	0	0	0	0	-1
22	80	30	G	0.002	0.111	0.106	0.044	0	0	0	0	81
22	80	50	S	0	0	0.101	0.109	0	0	0	0	-1
22	80	50	K	0.004	0.036	0.003	0.003	0	0	0	0	-1
22	80	50	G	0.004	0.036	0.104	0.112	0	0	0	0	81
22	80	70	S	0	0	0.093	0.067	0	0	0	0	-1
22	80	70	K	0.004	0.058	0.01	0.012	0	0	0	0	-1
22	80	70	G	0.004	0.058	0.103	0.079	0	0	0	0	80
22	100	30	S	0	0.11	0.14	0.062	0	0	0	0	-1
22	100	30	K	0.001	0.017	0	0	0	0	0	0	-1
22	100	30	G	0.001	0.127	0.14	0.062	0	0	0	0	81
22	100	50	S	0	0	0.134	0.129	0	0	0	0	-1
22	100	50	K	0.003	0.045	0.007	0.004	0	0	0	0	-1
22	100	50	G	0.003	0.045	0.141	0.133	0	0	0	0	82
22	100	70	S	0	0	0.124	0.076	0	0	0	0	-1
22	100	70	K	0.004	0.073	0.016	0.015	0	0	0	0	-1
22	100	70	G	0.004	0.073	0.14	0.091	0	0	0	0	81
22	120	30	S	0	0.119	0.174	0.081	0	0	0	0	-1
22	120	30	K	0.001	0.02	0.003	0	0	0	0	0	-1
22	120	30	G	0.001	0.139	0.177	0.081	0	0	0	0	82
22	120	50	S	0	0	0.167	0.147	0	0	0	0	-1
22	120	50	K	0.003	0.054	0.012	0.004	0	0	0	0	-1
22	120	50	G	0.003	0.054	0.179	0.151	0	0	0	0	82
22	120	70	S	0	0	0.154	0.083	0	0	0	0	-1
22	120	70	K	0.005	0.089	0.022	0.018	0	0	0	0	-1
22	120	70	G	0.005	0.089	0.176	0.101	0	0	0	0	81
23	60	50	S	0	0	0.075	0.104	0	0	0	0	-1
23	60	50	K	0.005	0.031	0.001	0.004	0	0	0	0	-1
23	60	50	G	0.005	0.031	0.076	0.108	0	0	0	0	81
23	60	70	S	0	0	0.069	0.067	0	0	0	0	-1
23	60	70	K	0.006	0.05	0.007	0.012	0	0	0	0	-1
23	60	70	G	0.006	0.05	0.076	0.079	0	0	0	0	81
23	80	30	S	0.001	0.098	0.114	0.072	0	0	0	0	-1

BHD	H/D	K%	SKG	kapp.	s.NH.	1b	2a	2b	3a	3b	4+	%D
23	80	30	K	0.002	0.015	0	0	0	0	0	0	-1
23	80	30	G	0.003	0.113	0.114	0.072	0	0	0	0	81
23	80	50	S	0	0	0.109	0.13	0	0	0	0	-1
23	80	50	K	0.004	0.041	0.004	0.006	0	0	0	0	-1
23	80	50	G	0.004	0.041	0.113	0.136	0	0	0	0	81
23	80	70	S	0	0	0.101	0.081	0	0	0	0	-1
23	80	70	K	0.005	0.067	0.012	0.016	0	0	0	0	-1
23	80	70	G	0.005	0.067	0.113	0.097	0	0	0	0	81
23	100	30	S	0	0.109	0.151	0.1	0	0	0	0	-1
23	100	30	K	0.001	0.019	0	0	0	0	0	0	-1
23	100	30	G	0.001	0.128	0.151	0.1	0	0	0	0	82
23	100	50	S	0	0	0.144	0.155	0	0	0	0	-1
23	100	50	K	0.003	0.052	0.009	0.007	0	0	0	0	-1
23	100	50	G	0.003	0.052	0.153	0.162	0	0	0	0	82
23	100	70	S	0	0	0.133	0.094	0	0	0	0	-1
23	100	70	K	0.005	0.084	0.019	0.02	0	0	0	0	-1
23	100	70	G	0.005	0.084	0.152	0.114	0	0	0	0	81
23	120	30	S	0	0.113	0.188	0.129	0	0	0	0	-1
23	120	30	K	0.002	0.023	0.005	0	0	0	0	0	-1
23	120	30	G	0.002	0.136	0.193	0.129	0	0	0	0	83
23	120	50	S	0	0	0.18	0.177	0	0	0	0	-1
23	120	50	K	0.004	0.062	0.015	0.008	0	0	0	0	-1
23	120	50	G	0.004	0.062	0.195	0.185	0	0	0	0	82
23	120	70	S	0	0	0.166	0.104	0	0	0	0	-1
23	120	70	K	0.006	0.102	0.027	0.024	0	0	0	0	-1
23	120	70	G	0.006	0.102	0.193	0.128	0	0	0	0	82
24	60	50	S	0	0	0.079	0.124	0	0	0	0	-1
24	60	50	K	0.006	0.035	0.001	0.006	0	0	0	0	-1
24	60	50	G	0.006	0.035	0.08	0.13	0	0	0	0	81
24	60	70	S	0	0	0.072	0.082	0	0	0	0	-1
24	60	70	K	0.007	0.057	0.008	0.015	0	0	0	0	-1
24	60	70	G	0.007	0.057	0.08	0.097	0	0	0	0	81
24	80	30	S	0.001	0.098	0.12	0.108	0	0	0	0	-1
24	80	30	K	0.002	0.017	0	0	0	0	0	0	-1
24	80	30	G	0.003	0.115	0.12	0.108	0	0	0	0	82
24	80	50	S	0	0	0.114	0.158	0	0	0	0	-1
24	80	50	K	0.004	0.047	0.005	0.009	0	0	0	0	-1
24	80	50	G	0.004	0.047	0.119	0.167	0	0	0	0	82
24	80	70	S	0	0	0.105	0.102	0	0	0	0	-1
24	80	70	K	0.005	0.076	0.014	0.021	0	0	0	0	-1
24	80	70	G	0.005	0.076	0.119	0.123	0	0	0	0	81
24	100	30	S	0	0.105	0.158	0.149	0	0	0	0	-1
24	100	30	K	0.001	0.021	0.001	0	0	0	0	0	-1
24	100	30	G	0.001	0.126	0.159	0.149	0	0	0	0	82
24	100	50	S	0	0	0.151	0.189	0	0	0	0	-1
24	100	50	K	0.003	0.059	0.011	0.011	0	0	0	0	-1
24	100	50	G	0.003	0.059	0.162	0.2	0	0	0	0	82
24	100	70	S	0	0	0.139	0.118	0	0	0	0	-1
24	100	70	K	0.005	0.096	0.022	0.026	0	0	0	0	-1
24	100	70	G	0.005	0.096	0.161	0.144	0	0	0	0	82
24	120	30	S	0	0.106	0.197	0.19	0	0	0	0	-1

BHD	H/D	K%	SKG	kapp.	s.NH.	1b	2a	2b	3a	3b	4+	%D
24	120	30	K	0.002	0.025	0.007	0	0	0	0	0	-1
24	120	30	G	0.002	0.131	0.204	0.19	0	0	0	0	83
24	120	50	S	0	0	0.188	0.217	0	0	0	0	-1
24	120	50	K	0.004	0.071	0.018	0.013	0	0	0	0	-1
24	120	50	G	0.004	0.071	0.206	0.23	0	0	0	0	83
24	120	70	S	0	0	0.173	0.132	0	0	0	0	-1
24	120	70	K	0.006	0.116	0.032	0.031	0	0	0	0	-1
24	120	70	G	0.006	0.116	0.205	0.163	0	0	0	0	82
25	60	50	S	0	0	0.08	0.15	0	0	0	0	-1
25	60	50	K	0.006	0.039	0.001	0.009	0	0	0	0	-1
25	60	50	G	0.006	0.039	0.081	0.159	0	0	0	0	81
25	60	70	S	0	0	0.073	0.102	0	0	0	0	-1
25	60	70	K	0.007	0.064	0.009	0.019	0	0	0	0	-1
25	60	70	G	0.007	0.064	0.082	0.121	0	0	0	0	81
25	80	30	S	0.002	0.096	0.123	0.151	0	0	0	0	-1
25	80	30	K	0.002	0.018	0	0	0	0	0	0	-1
25	80	30	G	0.004	0.114	0.123	0.151	0	0	0	0	82
25	80	50	S	0	0	0.117	0.192	0	0	0	0	-1
25	80	50	K	0.004	0.052	0.006	0.012	0	0	0	0	-1
25	80	50	G	0.004	0.052	0.123	0.204	0	0	0	0	82
25	80	70	S	0	0	0.106	0.127	0	0	0	0	-1
25	80	70	K	0.006	0.086	0.016	0.026	0	0	0	0	-1
25	80	70	G	0.006	0.086	0.122	0.153	0	0	0	0	81
25	100	30	S	0	0.1	0.162	0.208	0	0	0	0	-1
25	100	30	K	0.001	0.023	0.002	0	0	0	0	0	-1
25	100	30	G	0.001	0.123	0.164	0.208	0	0	0	0	83
25	100	50	S	0	0	0.154	0.23	0	0	0	0	-1
25	100	50	K	0.004	0.066	0.013	0.015	0	0	0	0	-1
25	100	50	G	0.004	0.066	0.167	0.245	0	0	0	0	82
25	100	70	S	0	0	0.141	0.15	0	0	0	0	-1
25	100	70	K	0.006	0.109	0.026	0.032	0	0	0	0	-1
25	100	70	G	0.006	0.109	0.167	0.182	0	0	0	0	82
25	120	30	S	0	0.095	0.201	0.264	0	0	0	0	-1
25	120	30	K	0.002	0.028	0.009	0	0	0	0	0	-1
25	120	30	G	0.002	0.123	0.21	0.264	0	0	0	0	83
25	120	50	S	0	0	0.192	0.266	0	0	0	0	-1
25	120	50	K	0.005	0.08	0.022	0.018	0	0	0	0	-1
25	120	50	G	0.005	0.08	0.214	0.284	0	0	0	0	83
25	120	70	S	0	0	0.176	0.169	0	0	0	0	-1
25	120	70	K	0.007	0.131	0.038	0.039	0	0	0	0	-1
25	120	70	G	0.007	0.131	0.214	0.208	0	0	0	0	83
26	60	50	S	0	0	0.079	0.12	0.061	0	0	0	-1
26	60	50	K	0.006	0.044	0.001	0.012	0	0	0	0	-1
26	60	50	G	0.006	0.044	0.08	0.132	0.061	0	0	0	82
26	60	70	S	0	0	0	0.102	0.087	0	0	0	-1
26	60	70	K	0.007	0.072	0.01	0.023	0.008	0	0	0	-1
26	60	70	G	0.007	0.072	0.01	0.125	0.095	0	0	0	81
26	80	30	S	0.003	0.094	0.122	0.174	0.03	0	0	0	-1
26	80	30	K	0.002	0.02	0	0	0	0	0	0	-1
26	80	30	G	0.005	0.114	0.122	0.174	0.03	0	0	0	82
26	80	50	S	0	0	0.116	0.15	0.082	0	0	0	-1

BHD	H/D	K%	SKG	kapp.	s.NH.	1b	2a	2b	3a	3b	4+	%D
26	80	50	K	0.004	0.059	0.007	0.016	0	0	0	0	-1
26	80	50	G	0.004	0.059	0.123	0.166	0.082	0	0	0	82
26	80	70	S	0	0	0	0.126	0.126	0	0	0	-1
26	80	70	K	0.006	0.097	0.018	0.031	0.011	0	0	0	-1
26	80	70	G	0.006	0.097	0.018	0.157	0.137	0	0	0	82
26	100	30	S	0	0.093	0.161	0.211	0.067	0	0	0	-1
26	100	30	K	0.001	0.025	0.003	0	0	0	0	0	-1
26	100	30	G	0.001	0.118	0.164	0.211	0.067	0	0	0	83
26	100	50	S	0	0	0.153	0.182	0.098	0	0	0	-1
26	100	50	K	0.004	0.074	0.015	0.02	0	0	0	0	-1
26	100	50	G	0.004	0.074	0.168	0.202	0.098	0	0	0	83
26	100	70	S	0	0	0	0.152	0.162	0	0	0	-1
26	100	70	K	0.006	0.122	0.03	0.039	0.014	0	0	0	-1
26	100	70	G	0.006	0.122	0.03	0.191	0.176	0	0	0	83
26	120	30	S	0	0.083	0.201	0.249	0.103	0	0	0	-1
26	120	30	K	0.002	0.031	0.012	0	0	0	0	0	-1
26	120	30	G	0.002	0.114	0.213	0.249	0.103	0	0	0	84
26	120	50	S	0	0	0.191	0.214	0.111	0	0	0	-1
26	120	50	K	0.005	0.09	0.027	0.024	0	0	0	0	-1
26	120	50	G	0.005	0.09	0.218	0.238	0.111	0	0	0	84
26	120	70	S	0	0	0	0.178	0.193	0	0	0	-1
26	120	70	K	0.008	0.148	0.044	0.047	0.016	0	0	0	-1
26	120	70	G	0.008	0.148	0.044	0.225	0.209	0	0	0	83
27	60	50	S	0	0	0	0.135	0.157	0	0	0	-1
27	60	50	K	0.007	0.049	0.001	0.015	0.001	0	0	0	-1
27	60	50	G	0.007	0.049	0.001	0.15	0.158	0	0	0	82
27	60	70	S	0	0	0	0.114	0.097	0	0	0	-1
27	60	70	K	0.008	0.081	0.011	0.027	0.01	0	0	0	-1
27	60	70	G	0.008	0.081	0.011	0.141	0.107	0	0	0	81
27	80	30	S	0	0.091	0.118	0.196	0.072	0	0	0	-1
27	80	30	K	0.002	0.022	0	0.001	0	0	0	0	-1
27	80	30	G	0.002	0.113	0.118	0.197	0.072	0	0	0	82
27	80	50	S	0	0	0	0.169	0.22	0	0	0	-1
27	80	50	K	0.004	0.065	0.008	0.02	0.002	0	0	0	-1
27	80	50	G	0.004	0.065	0.008	0.189	0.222	0	0	0	82
27	80	70	S	0	0	0	0.142	0.14	0	0	0	-1
27	80	70	K	0.006	0.109	0.021	0.037	0.014	0	0	0	-1
27	80	70	G	0.006	0.109	0.021	0.179	0.154	0	0	0	82
27	100	30	S	0	0	0.157	0.238	0.205	0	0	0	-1
27	100	30	K	0.001	0.028	0.004	0.001	0	0	0	0	-1
27	100	30	G	0.001	0.028	0.161	0.239	0.205	0	0	0	83
27	100	50	S	0	0	0	0.205	0.28	0	0	0	-1
27	100	50	K	0.004	0.082	0.018	0.025	0.002	0	0	0	-1
27	100	50	G	0.004	0.082	0.018	0.23	0.282	0	0	0	83
27	100	70	S	0	0	0	0.171	0.179	0	0	0	-1
27	100	70	K	0.007	0.137	0.034	0.046	0.018	0	0	0	-1
27	100	70	G	0.007	0.137	0.034	0.217	0.197	0	0	0	83
27	120	30	S	0	0	0.195	0.281	0.239	0	0	0	-1
27	120	30	K	0.002	0.033	0.015	0.002	0	0	0	0	-1
27	120	30	G	0.002	0.033	0.21	0.283	0.239	0	0	0	84
27	120	50	S	0	0	0	0.241	0.335	0	0	0	-1

BHD	H/D	K%	SKG	kapp.	s.NH.	1b	2a	2b	3a	3b	4+	%D
27	120	50	K	0.006	0.1	0.032	0.03	0.003	0	0	0	-1
27	120	50	G	0.006	0.1	0.032	0.271	0.338	0	0	0	84
27	120	70	S	0	0	0	0.2	0.213	0	0	0	-1
27	120	70	K	0.009	0.166	0.051	0.056	0.021	0	0	0	-1
27	120	70	G	0.009	0.166	0.051	0.256	0.234	0	0	0	83
28	60	50	S	0	0	0	0.147	0.178	0	0	0	-1
28	60	50	K	0.007	0.054	0.001	0.018	0.003	0	0	0	-1
28	60	50	G	0.007	0.054	0.001	0.165	0.181	0	0	0	82
28	60	70	S	0	0	0	0.124	0.112	0	0	0	-1
28	60	70	K	0.008	0.09	0.012	0.032	0.013	0	0	0	-1
28	60	70	G	0.008	0.09	0.012	0.156	0.125	0	0	0	81
28	80	30	S	0	0.087	0.112	0.216	0.121	0	0	0	-1
28	80	30	K	0.002	0.023	0	0.003	0	0	0	0	-1
28	80	30	G	0.002	0.11	0.112	0.219	0.121	0	0	0	83
28	80	50	S	0	0	0	0.186	0.249	0	0	0	-1
28	80	50	K	0.005	0.072	0.009	0.024	0.004	0	0	0	-1
28	80	50	G	0.005	0.072	0.009	0.21	0.253	0	0	0	83
28	80	70	S	0	0	0	0.156	0.159	0	0	0	-1
28	80	70	K	0.007	0.121	0.024	0.043	0.017	0	0	0	-1
28	80	70	G	0.007	0.121	0.024	0.199	0.176	0	0	0	82
28	100	30	S	0	0	0.148	0.264	0.261	0	0	0	-1
28	100	30	K	0.001	0.03	0.005	0.004	0	0	0	0	-1
28	100	30	G	0.001	0.03	0.153	0.268	0.261	0	0	0	84
28	100	50	S	0	0	0	0.226	0.315	0	0	0	-1
28	100	50	K	0.004	0.091	0.021	0.03	0.005	0	0	0	-1
28	100	50	G	0.004	0.091	0.021	0.256	0.32	0	0	0	83
28	100	70	S	0	0	0	0.188	0.201	0	0	0	-1
28	100	70	K	0.007	0.153	0.039	0.055	0.022	0	0	0	-1
28	100	70	G	0.007	0.153	0.039	0.243	0.223	0	0	0	83
28	120	30	S	0	0	0.185	0.312	0.304	0	0	0	-1
28	120	30	K	0.002	0.036	0.018	0.005	0	0	0	0	-1
28	120	30	G	0.002	0.036	0.203	0.317	0.304	0	0	0	84
28	120	50	S	0	0	0	0.267	0.375	0	0	0	-1
28	120	50	K	0.006	0.11	0.037	0.037	0.006	0	0	0	-1
28	120	50	G	0.006	0.11	0.037	0.304	0.381	0	0	0	84
28	120	70	S	0	0	0	0.221	0.238	0	0	0	-1
28	120	70	K	0.01	0.185	0.059	0.066	0.027	0	0	0	-1
28	120	70	G	0.01	0.185	0.059	0.287	0.265	0	0	0	84
29	60	50	S	0	0	0	0.157	0.206	0	0	0	-1
29	60	50	K	0.007	0.059	0.001	0.021	0.005	0	0	0	-1
29	60	50	G	0.007	0.059	0.001	0.178	0.211	0	0	0	82
29	60	70	S	0	0	0	0.132	0.131	0	0	0	-1
29	60	70	K	0.009	0.099	0.013	0.037	0.016	0	0	0	-1
29	60	70	G	0.009	0.099	0.013	0.169	0.147	0	0	0	81
29	80	30	S	0	0.082	0.102	0.234	0.181	0	0	0	-1
29	80	30	K	0.002	0.025	0	0.005	0	0	0	0	-1
29	80	30	G	0.002	0.107	0.102	0.239	0.181	0	0	0	83
29	80	50	S	0	0	0	0.201	0.284	0	0	0	-1
29	80	50	K	0.005	0.079	0.01	0.029	0.006	0	0	0	-1
29	80	50	G	0.005	0.079	0.01	0.23	0.29	0	0	0	83
29	80	70	S	0	0	0	0.168	0.183	0	0	0	-1

BHD	H/D	K%	SKG	kapp.	s.NH.	1b	2a	2b	3a	3b	4+	%D
29	80	70	K	0.007	0.134	0.027	0.05	0.021	0	0	0	-1
29	80	70	G	0.007	0.134	0.027	0.218	0.204	0	0	0	83
29	100	30	S	0	0	0.136	0.288	0.328	0	0	0	-1
29	100	30	K	0.001	0.031	0.006	0.007	0	0	0	0	-1
29	100	30	G	0.001	0.031	0.142	0.295	0.328	0	0	0	84
29	100	50	S	0	0	0	0.246	0.356	0	0	0	-1
29	100	50	K	0.005	0.1	0.024	0.036	0.008	0	0	0	-1
29	100	50	G	0.005	0.1	0.024	0.282	0.364	0	0	0	84
29	100	70	S	0	0	0	0.204	0.229	0	0	0	-1
29	100	70	K	0.008	0.169	0.045	0.063	0.027	0	0	0	-1
29	100	70	G	0.008	0.169	0.045	0.267	0.256	0	0	0	83
29	120	30	S	0	0	0.171	0.341	0.383	0	0	0	-1
29	120	30	K	0.003	0.038	0.022	0.008	0	0	0	0	-1
29	120	30	G	0.003	0.038	0.193	0.349	0.383	0	0	0	85
29	120	50	S	0	0	0	0.291	0.422	0	0	0	-1
29	120	50	K	0.007	0.122	0.043	0.044	0.009	0	0	0	-1
29	120	50	G	0.007	0.122	0.043	0.335	0.431	0	0	0	84
29	120	70	S	0	0	0	0.241	0.269	0	0	0	-1
29	120	70	K	0.011	0.205	0.068	0.077	0.033	0	0	0	-1
29	120	70	G	0.011	0.205	0.068	0.318	0.302	0	0	0	84
30	60	50	S	0	0	0	0.165	0.239	0	0	0	-1
30	60	50	K	0.007	0.065	0.001	0.025	0.007	0	0	0	-1
30	60	50	G	0.007	0.065	0.001	0.19	0.246	0	0	0	82
30	60	70	S	0	0	0	0.138	0.155	0	0	0	-1
30	60	70	K	0.009	0.11	0.015	0.043	0.019	0	0	0	-1
30	60	70	G	0.009	0.11	0.015	0.181	0.174	0	0	0	82
30	80	30	S	0	0.077	0.089	0.251	0.251	0	0	0	-1
30	80	30	K	0.002	0.026	0	0.008	0	0	0	0	-1
30	80	30	G	0.002	0.103	0.089	0.259	0.251	0	0	0	83
30	80	50	S	0	0	0	0.214	0.325	0	0	0	-1
30	80	50	K	0.005	0.087	0.011	0.034	0.009	0	0	0	-1
30	80	50	G	0.005	0.087	0.011	0.248	0.334	0	0	0	83
30	80	70	S	0	0	0	0.177	0.212	0	0	0	-1
30	80	70	K	0.008	0.148	0.03	0.058	0.026	0	0	0	-1
30	80	70	G	0.008	0.148	0.03	0.235	0.238	0	0	0	83
30	100	30	S	0	0	0.12	0.31	0.408	0	0	0	-1
30	100	30	K	0.001	0.033	0.008	0.01	0	0	0	0	-1
30	100	30	G	0.001	0.033	0.128	0.32	0.408	0	0	0	84
30	100	50	S	0	0	0	0.264	0.405	0	0	0	-1
30	100	50	K	0.005	0.11	0.028	0.043	0.011	0	0	0	-1
30	100	50	G	0.005	0.11	0.028	0.307	0.416	0	0	0	84
30	100	70	S	0	0	0	0.218	0.262	0	0	0	-1
30	100	70	K	0.009	0.187	0.051	0.073	0.032	0	0	0	-1
30	100	70	G	0.009	0.187	0.051	0.291	0.294	0	0	0	84
30	120	30	S	0	0	0.152	0.37	0.475	0	0	0	-1
30	120	30	K	0.003	0.04	0.026	0.012	0	0	0	0	-1
30	120	30	G	0.003	0.04	0.178	0.382	0.475	0	0	0	85
30	120	50	S	0	0	0	0.315	0.477	0	0	0	-1
30	120	50	K	0.008	0.133	0.05	0.052	0.013	0	0	0	-1
30	120	50	G	0.008	0.133	0.05	0.367	0.49	0	0	0	85
30	120	70	S	0	0	0	0.258	0.305	0	0	0	-1

BHD	H/D	K%	SKG	kapp.	s.NH.	1b	2a	2b	3a	3b	4+	%D
30	120	70	K	0.012	0.226	0.077	0.088	0.039	0	0	0	-1
30	120	70	G	0.012	0.226	0.077	0.346	0.344	0	0	0	84
32	60	50	S	0	0	0	0.174	0.196	0.127	0	0	-1
32	60	50	K	0.008	0.076	0	0.033	0.011	0	0	0	-1
32	60	50	G	0.008	0.076	0	0.207	0.207	0.127	0	0	83
32	60	70	S	0	0	0	0	0.166	0.176	0	0	-1
32	60	70	K	0.01	0.132	0.018	0.055	0.026	0.018	0	0	-1
32	60	70	G	0.01	0.132	0.018	0.055	0.192	0.194	0	0	82
32	80	30	S	0	0.067	0.056	0.278	0.285	0.14	0	0	-1
32	80	30	K	0.001	0.028	0	0.013	0	0	0	0	-1
32	80	30	G	0.001	0.095	0.056	0.291	0.285	0.14	0	0	84
32	80	50	S	0	0	0	0.234	0.264	0.164	0	0	-1
32	80	50	K	0.006	0.103	0.015	0.045	0.015	0	0	0	-1
32	80	50	G	0.006	0.103	0.015	0.279	0.279	0.164	0	0	84
32	80	70	S	0	0	0	0	0.224	0.23	0	0	-1
32	80	70	K	0.009	0.178	0.038	0.074	0.035	0.024	0	0	-1
32	80	70	G	0.009	0.178	0.038	0.074	0.259	0.254	0	0	83
32	100	30	S	0	0	0.079	0.351	0.36	0.243	0	0	-1
32	100	30	K	0.001	0.035	0.012	0.016	0	0	0	0	-1
32	100	30	G	0.001	0.035	0.091	0.367	0.36	0.243	0	0	85
32	100	50	S	0	0	0	0.295	0.334	0.191	0	0	-1
32	100	50	K	0.006	0.13	0.036	0.057	0.019	0	0	0	-1
32	100	50	G	0.006	0.13	0.036	0.352	0.353	0.191	0	0	85
32	100	70	S	0	0	0	0	0.283	0.274	0	0	-1
32	100	70	K	0.011	0.225	0.065	0.094	0.045	0.03	0	0	-1
32	100	70	G	0.011	0.225	0.065	0.094	0.328	0.304	0	0	84
32	120	30	S	0	0	0.102	0.425	0.436	0.264	0	0	-1
32	120	30	K	0.004	0.042	0.036	0.02	0	0	0	0	-1
32	120	30	G	0.004	0.042	0.138	0.445	0.436	0.264	0	0	86
32	120	50	S	0	0	0	0.357	0.404	0.207	0	0	-1
32	120	50	K	0.01	0.158	0.065	0.069	0.023	0	0	0	-1
32	120	50	G	0.01	0.158	0.065	0.426	0.427	0.207	0	0	85
32	120	70	S	0	0	0	0	0.343	0.309	0	0	-1
32	120	70	K	0.015	0.273	0.099	0.113	0.054	0.037	0	0	-1
32	120	70	G	0.015	0.273	0.099	0.113	0.397	0.346	0	0	85
34	60	50	S	0	0	0	0	0.241	0.361	0	0	-1
34	60	50	K	0.009	0.089	0	0.042	0.016	0.004	0	0	-1
34	60	50	G	0.009	0.089	0	0.042	0.257	0.365	0	0	83
34	60	70	S	0	0	0	0	0.204	0.209	0	0	-1
34	60	70	K	0.012	0.157	0.021	0.069	0.035	0.026	0	0	-1
34	60	70	G	0.012	0.157	0.021	0.069	0.239	0.235	0	0	83
34	80	30	S	0	0	0	0.299	0.351	0.358	0	0	-1
34	80	30	K	0.001	0.028	0	0.018	0.003	0	0	0	-1
34	80	30	G	0.001	0.028	0	0.317	0.354	0.358	0	0	84
34	80	50	S	0	0	0	0	0.326	0.476	0	0	-1
34	80	50	K	0.006	0.12	0.018	0.057	0.022	0.005	0	0	-1
34	80	50	G	0.006	0.12	0.018	0.057	0.348	0.481	0	0	84
34	80	70	S	0	0	0	0	0.276	0.27	0	0	-1
34	80	70	K	0.01	0.212	0.046	0.093	0.047	0.035	0	0	-1
34	80	70	G	0.01	0.212	0.046	0.093	0.323	0.305	0	0	84
34	100	30	S	0	0	0	0.387	0.444	0.428	0	0	-1

BHD	H/D	K%	SKG	kapp.	s.NH.	1b	2a	2b	3a	3b	4+	%D
34	100	30	K	0.001	0.035	0.016	0.023	0.004	0	0	0	-1
34	100	30	G	0.001	0.035	0.016	0.41	0.448	0.428	0	0	85
34	100	50	S	0	0	0	0	0.411	0.579	0	0	-1
34	100	50	K	0.007	0.151	0.046	0.072	0.028	0.007	0	0	-1
34	100	50	G	0.007	0.151	0.046	0.072	0.439	0.586	0	0	85
34	100	70	S	0	0	0	0	0.349	0.32	0	0	-1
34	100	70	K	0.013	0.268	0.081	0.117	0.06	0.044	0	0	-1
34	100	70	G	0.013	0.268	0.081	0.117	0.409	0.364	0	0	85
36	60	50	S	0	0	0	0	0.282	0.252	0.19	0	-1
36	60	50	K	0.01	0.102	0	0.053	0.023	0.009	0	0	-1
36	60	50	G	0.01	0.102	0	0.053	0.305	0.261	0.19	0	84
36	60	70	S	0	0	0	0	0	0.207	0.281	0	-1
36	60	70	K	0.013	0.184	0.025	0.084	0.045	0.036	0.009	0	-1
36	60	70	G	0.013	0.184	0.025	0.084	0.045	0.243	0.29	0	83
36	80	30	S	0	0	0	0.312	0.412	0.371	0.124	0	-1
36	80	30	K	0.001	0.026	0	0.024	0.008	0	0	0	-1
36	80	30	G	0.001	0.026	0	0.336	0.42	0.371	0.124	0	85
36	80	50	S	0	0	0	0	0.381	0.34	0.24	0	-1
36	80	50	K	0.007	0.137	0.023	0.071	0.031	0.013	0	0	-1
36	80	50	G	0.007	0.137	0.023	0.071	0.412	0.353	0.24	0	85
36	80	70	S	0	0	0	0	0	0.28	0.363	0	-1
36	80	70	K	0.012	0.249	0.056	0.114	0.061	0.049	0.012	0	-1
36	80	70	G	0.012	0.249	0.056	0.114	0.061	0.329	0.375	0	85
36	100	30	S	0	0	0	0.418	0.521	0.469	0.11	0	-1
36	100	30	K	0.001	0.033	0.022	0.031	0.01	0	0	0	-1
36	100	30	G	0.001	0.033	0.022	0.449	0.531	0.469	0.11	0	86
36	100	50	S	0	0	0	0	0.482	0.43	0.274	0	-1
36	100	50	K	0.009	0.174	0.058	0.09	0.039	0.016	0	0	-1
36	100	50	G	0.009	0.174	0.058	0.09	0.521	0.446	0.274	0	86
36	100	70	S	0	0	0	0	0	0.354	0.43	0	-1
36	100	70	K	0.016	0.315	0.1	0.144	0.077	0.062	0.015	0	-1
36	100	70	G	0.016	0.315	0.1	0.144	0.077	0.416	0.445	0	86
38	60	50	S	0	0	0	0	0.316	0.329	0.219	0	-1
38	60	50	K	0.01	0.115	0	0.064	0.03	0.016	0	0	-1
38	60	50	G	0.01	0.115	0	0.064	0.346	0.345	0.219	0	84
38	60	70	S	0	0	0	0	0	0.275	0.301	0	-1
38	60	70	K	0.015	0.214	0.03	0.102	0.057	0.048	0.017	0	-1
38	60	70	G	0.015	0.214	0.03	0.102	0.057	0.323	0.318	0	84
38	80	30	S	0	0	0	0	0.463	0.483	0.513	0	-1
38	80	30	K	0.002	0.02	0	0.03	0.014	0.003	0	0	-1
38	80	30	G	0.002	0.02	0	0.03	0.477	0.486	0.513	0	86
38	80	50	S	0	0	0	0	0.428	0.445	0.275	0	-1
38	80	50	K	0.008	0.155	0.028	0.086	0.041	0.022	0	0	-1
38	80	50	G	0.008	0.155	0.028	0.086	0.469	0.467	0.275	0	86
38	80	70	S	0	0	0	0	0	0.372	0.385	0	-1
38	80	70	K	0.014	0.29	0.068	0.138	0.077	0.065	0.024	0	-1
38	80	70	G	0.014	0.29	0.068	0.138	0.077	0.437	0.409	0	85
38	100	30	S	0	0	0	0	0.586	0.611	0.619	0	-1
38	100	30	K	0.002	0.027	0.028	0.038	0.017	0.004	0	0	-1
38	100	30	G	0.002	0.027	0.028	0.038	0.603	0.615	0.619	0	87
38	100	50	S	0	0	0	0	0.54	0.563	0.31	0	-1

BHD	H/D	K%	SKG	kapp.	s.NH.	1b	2a	2b	3a	3b	4+	%D
38	100	50	K	0.011	0.196	0.072	0.109	0.052	0.028	0	0	-1
38	100	50	G	0.011	0.196	0.072	0.109	0.592	0.591	0.31	0	86
38	100	70	S	0	0	0	0	0	0.47	0.451	0	-1
38	100	70	K	0.019	0.366	0.121	0.174	0.097	0.082	0.03	0	-1
38	100	70	G	0.019	0.366	0.121	0.174	0.097	0.552	0.481	0	86
40	60	50	S	0	0	0	0	0	0.399	0.621	0	-1
40	60	50	K	0.011	0.128	0	0.076	0.039	0.025	0.005	0	-1
40	60	50	G	0.011	0.128	0	0.076	0.039	0.424	0.626	0	85
40	60	70	S	0	0	0	0	0	0.334	0.342	0	-1
40	60	70	K	0.017	0.246	0.035	0.121	0.07	0.062	0.028	0	-1
40	60	70	G	0.017	0.246	0.035	0.121	0.07	0.396	0.37	0	84
40	80	30	S	0	0	0	0	0.5	0.585	0.645	0	-1
40	80	30	K	0.002	0.012	0	0.037	0.021	0.011	0	0	-1
40	80	30	G	0.002	0.012	0	0.037	0.521	0.596	0.645	0	86
40	80	50	S	0	0	0	0	0	0.54	0.813	0	-1
40	80	50	K	0.009	0.173	0.034	0.103	0.053	0.034	0.007	0	-1
40	80	50	G	0.009	0.173	0.034	0.103	0.053	0.574	0.82	0	86
40	80	70	S	0	0	0	0	0	0.453	0.435	0	-1
40	80	70	K	0.017	0.333	0.082	0.164	0.095	0.084	0.038	0	-1
40	80	70	G	0.017	0.333	0.082	0.164	0.095	0.537	0.473	0	86
42	60	50	S	0	0	0	0	0	0.457	0.263	0.476	-1
42	60	50	K	0.013	0.141	0	0.089	0.049	0.035	0.014	0	-1
42	60	50	G	0.013	0.141	0	0.089	0.049	0.492	0.277	0.476	85
42	60	70	S	0	0	0	0	0	0	0.187	0.599	-1
42	60	70	K	0.019	0.281	0.041	0.143	0.086	0.079	0.04	0.007	-1
42	60	70	G	0.019	0.281	0.041	0.143	0.086	0.079	0.227	0.606	85
42	80	30	S	0	0	0	0	0	0.672	0.461	0.905	-1
42	80	30	K	0.001	0.002	0	0.043	0.029	0.021	0.002	0	-1
42	80	30	G	0.001	0.002	0	0.043	0.029	0.693	0.463	0.905	87
42	80	50	S	0	0	0	0	0	0.619	0.356	0.611	-1
42	80	50	K	0.011	0.191	0.04	0.121	0.067	0.048	0.018	0	-1
42	80	50	G	0.011	0.191	0.04	0.121	0.067	0.667	0.374	0.611	87
42	80	70	S	0	0	0	0	0	0	0.253	0.776	-1
42	80	70	K	0.019	0.38	0.097	0.193	0.116	0.107	0.054	0.009	-1
42	80	70	G	0.019	0.38	0.097	0.193	0.116	0.107	0.307	0.785	86
44	60	50	S	0	0	0	0	0	0.499	0.307	0.59	-1
44	60	50	K	0.014	0.153	0	0.104	0.061	0.048	0.023	0	-1
44	60	50	G	0.014	0.153	0	0.104	0.061	0.547	0.33	0.59	86
44	60	70	S	0	0	0	0	0	0	0.219	0.685	-1
44	60	70	K	0.021	0.317	0.047	0.166	0.104	0.099	0.054	0.022	-1
44	60	70	G	0.021	0.317	0.047	0.166	0.104	0.099	0.273	0.707	86
44	80	30	S	0	0	0	0	0	0.735	0.539	1.091	-1
44	80	30	K	0.001	0	0	0.048	0.038	0.034	0.013	0	-1
44	80	30	G	0.001	0	0	0.048	0.038	0.769	0.552	1.091	87
44	80	50	S	0	0	0	0	0	0.675	0.416	0.757	-1
44	80	50	K	0.013	0.208	0.048	0.14	0.082	0.064	0.032	0	-1
44	80	50	G	0.013	0.208	0.048	0.14	0.082	0.739	0.448	0.757	87
44	80	70	S	0	0	0	0	0	0	0.296	0.882	-1
44	80	70	K	0.023	0.43	0.114	0.225	0.141	0.133	0.073	0.03	-1
44	80	70	G	0.023	0.43	0.114	0.225	0.141	0.133	0.369	0.912	87
46	60	50	S	0	0	0	0	0	0	0.358	1.258	-1

BHD	H/D	K%	SKG	kapp.	s.NH.	1b	2a	2b	3a	3b	4+	%D
46	60	50	K	0.016	0.165	0	0.119	0.074	0.062	0.035	0.007	-1
46	60	50	G	0.016	0.165	0	0.119	0.074	0.062	0.393	1.265	87
46	60	70	S	0	0	0	0	0	0	0.254	0.78	-1
46	60	70	K	0.024	0.356	0.054	0.192	0.124	0.121	0.07	0.042	-1
46	60	70	G	0.024	0.356	0.054	0.192	0.124	0.121	0.324	0.822	86
46	80	30	S	0	0	0	0	0	0.767	0.627	1.334	-1
46	80	30	K	0.001	0	0	0.054	0.049	0.048	0.026	0	-1
46	80	30	G	0.001	0	0	0.054	0.049	0.815	0.653	1.334	88
46	80	50	S	0	0	0	0	0	0	0.484	1.652	-1
46	80	50	K	0.015	0.223	0.056	0.161	0.1	0.084	0.047	0.01	-1
46	80	50	G	0.015	0.223	0.056	0.161	0.1	0.084	0.531	1.662	88
46	80	70	S	0	0	0	0	0	0	0.344	1.001	-1
46	80	70	K	0.027	0.482	0.133	0.259	0.168	0.164	0.095	0.056	-1
46	80	70	G	0.027	0.482	0.133	0.259	0.168	0.164	0.439	1.057	87
48	60	50	S	0	0	0	0	0	0	0.414	1.436	-1
48	60	50	K	0.018	0.175	0	0.135	0.089	0.079	0.048	0.027	-1
48	60	50	G	0.018	0.175	0	0.135	0.089	0.079	0.462	1.463	87
48	60	70	S	0	0	0	0	0	0	0.294	0.888	-1
48	60	70	K	0.028	0.396	0.062	0.219	0.147	0.147	0.088	0.064	-1
48	60	70	G	0.028	0.396	0.062	0.219	0.147	0.147	0.382	0.952	87
48	80	30	S	0	0	0	0	0	0	0.725	2.394	-1
48	80	30	K	0.002	0	0	0.059	0.061	0.065	0.04	0.013	-1
48	80	30	G	0.002	0	0	0.059	0.061	0.065	0.765	2.407	89
48	80	50	S	0	0	0	0	0	0	0.56	1.884	-1
48	80	50	K	0.019	0.236	0.066	0.182	0.12	0.106	0.065	0.037	-1
48	80	50	G	0.019	0.236	0.066	0.182	0.12	0.106	0.625	1.921	88
48	80	70	S	0	0	0	0	0	0	0.398	1.202	-1
48	80	70	K	0.032	0.537	0.155	0.297	0.198	0.199	0.119	0.021	-1
48	80	70	G	0.032	0.537	0.155	0.297	0.198	0.199	0.517	1.223	88
50	60	50	S	0	0	0	0	0	0	0.476	1.635	-1
50	60	50	K	0.02	0.182	0	0.151	0.106	0.098	0.063	0.053	-1
50	60	50	G	0.02	0.182	0	0.151	0.106	0.098	0.539	1.688	88
50	60	70	S	0	0	0	0	0	0	0.339	1.1	-1
50	60	70	K	0.032	0.439	0.071	0.249	0.172	0.176	0.109	0	-1
50	60	70	G	0.032	0.439	0.071	0.249	0.172	0.176	0.448	1.1	87

Appendix 1.3 *Picea abies*, single tree assortment tables

BHD	H/D	Kapp.	s.NH	1b	2a	2b	3a	3b	4+	%S	%D
10	120	0.002	0.023	0	0	0	0	0	0	47	57
11	100	0.002	0.029	0	0	0	0	0	0	55	62
11	120	0.002	0.036	0	0	0	0	0	0	55	62
12	90	0.002	0.037	0	0	0	0	0	0	59	64
12	100	0.002	0.041	0	0	0	0	0	0	59	64
12	120	0.002	0.051	0	0	0	0	0	0	59	65
13	80	0.002	0.041	0	0	0	0	0	0	59	64
13	90	0.002	0.049	0	0	0	0	0	0	62	66
13	100	0.002	0.056	0	0	0	0	0	0	63	67
13	120	0.002	0.069	0	0	0	0	0	0	63	68
14	80	0.002	0.055	0	0	0	0	0	0	63	67
14	90	0.002	0.063	0	0	0	0	0	0	64	68
14	100	0.002	0.073	0	0	0	0	0	0	65	69
14	120	0.002	0.09	0	0	0	0	0	0	66	69
15	70	0.002	0.057	0	0	0	0	0	0	63	66
15	80	0.002	0.069	0	0	0	0	0	0	66	69
15	90	0.002	0.081	0	0	0	0	0	0	67	70
15	100	0.002	0.092	0	0	0	0	0	0	67	70
15	120	0.002	0.113	0	0	0	0	0	0	68	71
16	70	0.002	0.071	0	0	0	0	0	0	66	69
16	80	0.002	0.086	0	0	0	0	0	0	68	70
16	90	0.002	0.1	0	0	0	0	0	0	68	71
16	100	0.002	0.114	0	0	0	0	0	0	69	71
16	120	0.002	0.141	0	0	0	0	0	0	69	72
17	60	0.002	0.07	0	0	0	0	0	0	65	67
17	70	0.002	0.088	0	0	0	0	0	0	68	70
17	80	0.002	0.105	0	0	0	0	0	0	69	71
17	90	0.002	0.121	0	0	0	0	0	0	70	72
17	100	0.002	0.138	0	0	0	0	0	0	70	72
17	120	0.002	0.171	0	0	0	0	0	0	71	73
18	60	0.002	0.084	0	0	0	0	0	0	67	69
18	70	0.002	0.106	0	0	0	0	0	0	70	72
18	80	0.002	0.127	0	0	0	0	0	0	71	72
18	90	0.002	0.146	0	0	0	0	0	0	71	73
18	100	0.002	0.158	0.008	0	0	0	0	0	71	73
18	120	0.002	0.161	0.044	0	0	0	0	0	72	74
19	60	0.002	0.101	0	0	0	0	0	0	69	70
19	70	0.002	0.126	0	0	0	0	0	0	71	73
19	80	0.002	0.15	0	0	0	0	0	0	72	73
19	90	0.002	0.135	0.039	0	0	0	0	0	72	74
19	100	0.002	0.106	0.092	0	0	0	0	0	73	74
19	120	0.002	0.125	0.12	0	0	0	0	0	73	75
20	60	0.002	0.12	0	0	0	0	0	0	70	72
20	70	0.002	0.149	0	0	0	0	0	0	72	73
20	80	0.002	0.174	0.003	0	0	0	0	0	73	74
20	90	0.002	0.097	0.105	0	0	0	0	0	73	74
20	100	0.002	0.098	0.133	0	0	0	0	0	73	74
20	120	0.002	0.116	0.171	0	0	0	0	0	74	75
21	60	0.002	0.14	0	0	0	0	0	0	71	73

BHD	H/D	Kapp.	s.NH	1b	2a	2b	3a	3b	4+	%S	%D
21	70	0.002	0.172	0	0	0	0	0	0	72	73
21	80	0.002	0.174	0.031	0	0	0	0	0	73	74
21	90	0.002	0.128	0.11	0	0	0	0	0	74	75
21	100	0.002	0.091	0.178	0	0	0	0	0	74	75
21	120	0.002	0.109	0.225	0	0	0	0	0	75	76
22	60	0.002	0.161	0	0	0	0	0	0	72	73
22	70	0.002	0.193	0.003	0.001	0	0	0	0	72	74
22	80	0.002	0.168	0.062	0.007	0	0	0	0	74	75
22	90	0.002	0.141	0.131	0	0	0	0	0	74	75
22	100	0.002	0.084	0.225	0.001	0	0	0	0	75	76
22	120	0.002	0.103	0.263	0.018	0	0	0	0	75	76
23	60	0.002	0.184	0	0	0	0	0	0	72	73
23	70	0.002	0.136	0.045	0.047	0	0	0	0	74	75
23	80	0.002	0.106	0.088	0.08	0	0	0	0	75	76
23	90	0.002	0.09	0.163	0.062	0	0	0	0	75	76
23	100	0.002	0.08	0.2	0.076	0	0	0	0	75	76
23	120	0.002	0.098	0.209	0.132	0	0	0	0	76	76
24	60	0.002	0.187	0.004	0.019	0	0	0	0	73	74
24	70	0.002	0.061	0.08	0.123	0	0	0	0	75	76
24	80	0.002	0.065	0.102	0.144	0	0	0	0	75	76
24	90	0.002	0.071	0.13	0.159	0	0	0	0	76	76
24	100	0.002	0.077	0.179	0.147	0	0	0	0	76	76
24	120	0.002	0.095	0.238	0.169	0	0	0	0	76	77
25	60	0.002	0.156	0.008	0.077	0	0	0	0	74	75
25	70	0.002	0.061	0.091	0.146	0	0	0	0	75	76
25	80	0.002	0.061	0.121	0.17	0	0	0	0	76	77
25	90	0.002	0.067	0.175	0.165	0	0	0	0	76	77
25	100	0.002	0.075	0.214	0.17	0	0	0	0	76	77
25	120	0.002	0.092	0.201	0.272	0	0	0	0	76	77
26	60	0.002	0.126	0.007	0.142	0	0	0	0	75	76
26	70	0.002	0.073	0.093	0.169	0	0	0	0	76	77
26	80	0.002	0.059	0.131	0.208	0	0	0	0	76	77
26	90	0.002	0.065	0.136	0.259	0	0	0	0	77	77
26	100	0.002	0.073	0.158	0.289	0	0	0	0	77	78
26	120	0.002	0.089	0.213	0.338	0	0	0	0	77	78
27	60	0.002	0.145	0.003	0.163	0	0	0	0	76	77
27	70	0.002	0.094	0.086	0.197	0	0	0	0	76	77
27	80	0.002	0.065	0.1	0.278	0	0	0	0	76	77
27	90	0.002	0.064	0.109	0.34	0	0	0	0	77	78
27	100	0.002	0.072	0.16	0.35	0	0	0	0	77	78
27	120	0.002	0.087	0.199	0.427	0	0	0	0	77	78
28	60	0.002	0.158	0.002	0.186	0	0	0	0	76	77
28	70	0.002	0.13	0.054	0.232	0.004	0	0	0	77	77
28	80	0.002	0.094	0.064	0.312	0.027	0	0	0	77	78
28	90	0.002	0.063	0.112	0.339	0.06	0	0	0	78	78
28	100	0.002	0.07	0.12	0.361	0.101	0	0	0	78	78
28	120	0.002	0.085	0.196	0.364	0.152	0	0	0	78	78
29	60	0.002	0.169	0	0.173	0.042	0	0	0	76	77
29	70	0.002	0.162	0.009	0.19	0.107	0	0	0	77	78
29	80	0.002	0.124	0.041	0.225	0.162	0	0	0	78	78
29	90	0.002	0.071	0.094	0.282	0.189	0	0	0	78	78

BHD	H/D	Kapp.	s.NH	1b	2a	2b	3a	3b	4+	%S	%D
29	100	0.002	0.069	0.103	0.336	0.213	0	0	0	78	78
29	120	0.002	0.083	0.187	0.402	0.216	0	0	0	78	78
30	60	0.002	0.152	0	0.151	0.124	0	0	0	77	77
30	70	0.002	0.159	0	0.171	0.19	0	0	0	78	78
30	80	0.002	0.144	0.026	0.221	0.225	0	0	0	78	79
30	90	0.002	0.1	0.061	0.321	0.226	0	0	0	78	79
30	100	0.002	0.068	0.102	0.379	0.25	0	0	0	78	79
30	120	0.002	0.082	0.17	0.408	0.324	0	0	0	78	79
32	60	0.002	0.115	0	0.145	0.262	0	0	0	78	78
32	70	0.002	0.158	0	0.211	0.265	0	0	0	78	79
32	80	0.002	0.16	0	0.259	0.327	0	0	0	78	79
32	90	0.002	0.143	0.023	0.306	0.385	0	0	0	79	79
32	100	0.002	0.08	0.083	0.331	0.476	0	0	0	79	79
32	120	0.002	0.079	0.15	0.388	0.574	0.002	0	0	79	79
34	60	0.002	0.129	0	0.204	0.218	0.082	0	0	78	79
34	70	0.002	0.142	0	0.201	0.306	0.113	0	0	79	79
34	80	0.002	0.162	0	0.189	0.384	0.165	0	0	79	79
34	90	0.002	0.159	0.001	0.264	0.385	0.216	0	0	79	79
34	100	0.002	0.107	0.057	0.312	0.451	0.228	0	0	79	80
34	120	0.002	0.076	0.132	0.365	0.572	0.277	0	0	80	80
36	60	0.002	0.103	0	0.133	0.227	0.291	0	0	79	79
36	70	0.002	0.148	0	0.189	0.257	0.312	0	0	79	80
36	80	0.002	0.154	0	0.183	0.4	0.326	0	0	80	80
36	90	0.002	0.163	0	0.195	0.525	0.338	0	0	80	80
36	100	0.002	0.14	0.023	0.288	0.539	0.378	0	0	80	80
36	120	0.002	0.074	0.112	0.342	0.629	0.522	0	0	80	80
38	60	0.002	0.1	0	0.131	0.293	0.366	0	0	80	80
38	70	0.002	0.137	0	0.156	0.382	0.395	0	0	80	80
38	80	0.002	0.159	0	0.179	0.421	0.484	0.005	0	80	80
38	90	0.002	0.159	0	0.167	0.481	0.597	0.026	0	80	80
38	100	0.002	0.156	0.007	0.252	0.519	0.612	0.066	0	80	80
40	60	0.002	0.098	0	0.088	0.369	0.285	0.19	0	80	80
40	70	0.002	0.134	0	0.142	0.322	0.349	0.297	0	80	80
40	80	0.002	0.154	0	0.176	0.368	0.41	0.352	0	80	81
40	90	0.002	0.161	0	0.173	0.458	0.492	0.382	0	80	81
40	100	0.002	0.16	0.001	0.2	0.491	0.62	0.407	0	81	81
42	60	0.002	0.087	0	0.088	0.261	0.325	0.435	0	80	81
42	70	0.002	0.137	0	0.11	0.357	0.389	0.442	0	81	81
42	80	0.002	0.154	0	0.169	0.295	0.616	0.451	0	81	81
42	90	0.002	0.158	0	0.171	0.419	0.693	0.489	0	81	81
42	100	0.002	0.161	0	0.18	0.455	0.777	0.594	0	81	81
44	60	0.002	0.086	0	0.088	0.277	0.437	0.479	0.011	81	81
44	70	0.002	0.126	0	0.097	0.304	0.57	0.493	0.064	81	81
44	80	0.002	0.154	0	0.155	0.301	0.603	0.589	0.131	81	81
44	90	0.002	0.16	0	0.172	0.33	0.665	0.7	0.178	81	81
44	100	0.002	0.16	0	0.166	0.453	0.748	0.726	0.233	81	81
46	60	0.002	0.079	0	0.094	0.241	0.467	0.271	0.422	81	81
46	70	0.002	0.126	0	0.083	0.294	0.48	0.419	0.492	81	81
46	80	0.002	0.153	0	0.152	0.277	0.611	0.485	0.525	81	81
46	90	0.002	0.158	0	0.168	0.304	0.673	0.673	0.541	81	81
48	60	0.002	0.079	0	0.091	0.244	0.37	0.429	0.57	81	81

BHD	H/D	Kapp.	s.NH	1b	2a	2b	3a	3b	4+	%S	%D
48	70	0.002	0.123	0	0.067	0.252	0.575	0.535	0.587	81	81
48	80	0.002	0.15	0	0.139	0.283	0.484	0.838	0.602	82	82
48	90	0.002	0.158	0	0.171	0.273	0.644	0.897	0.718	82	82
50	60	0.002	0.073	0	0.098	0.245	0.382	0.589	0.633	81	82
50	70	0.002	0.118	0	0.065	0.243	0.464	0.76	0.763	82	82
50	80	0.002	0.149	0	0.131	0.272	0.483	0.768	1.015	82	82
50	90	0.002	0.158	0	0.167	0.258	0.592	0.873	1.169	82	82

Appendix 1.4 *Pinus silvestris*, single tree assortment tables

BHD	H/D	kapp.	s.NH.	1b	2a	2b	3a	3b	4+	%S	%D
10	120	0.002	0.01	0	0	0	0	0	0	27	41
11	120	0.002	0.021	0	0	0	0	0	0	37	43
12	100	0.002	0.022	0	0	0	0	0	0	36	50
12	120	0.002	0.033	0	0	0	0	0	0	45	45
13	100	0.002	0.035	0	0	0	0	0	0	44	49
13	120	0.002	0.047	0	0	0	0	0	0	49	49
14	90	0.002	0.038	0	0	0	0	0	0	43	50
14	100	0.002	0.049	0	0	0	0	0	0	50	49
14	120	0.002	0.061	0	0	0	0	0	0	52	51
15	80	0.002	0.042	0	0	0	0	0	0	43	54
15	90	0.002	0.057	0	0	0	0	0	0	51	52
15	100	0.002	0.065	0	0	0	0	0	0	54	53
15	120	0.002	0.078	0	0	0	0	0	0	54	52
16	80	0.002	0.057	0	0	0	0	0	0	48	54
16	90	0.002	0.072	0	0	0	0	0	0	54	53
16	100	0.002	0.082	0	0	0	0	0	0	55	54
16	120	0.002	0.098	0	0	0	0	0	0	56	54
17	70	0.002	0.057	0	0	0	0	0	0	46	56
17	80	0.002	0.077	0	0	0	0	0	0	54	54
17	90	0.002	0.088	0	0	0	0	0	0	55	54
17	100	0.002	0.1	0	0	0	0	0	0	56	54
17	120	0.002	0.122	0	0	0	0	0	0	57	56
18	70	0.002	0.074	0	0	0	0	0	0	49	55
18	80	0.002	0.095	0	0	0	0	0	0	56	54
18	90	0.002	0.106	0	0	0	0	0	0	56	54
18	100	0.002	0.118	0	0	0	0	0	0	56	55
18	120	0.002	0.141	0	0	0	0	0	0	57	55
19	70	0.002	0.093	0	0	0	0	0	0	53	55
19	80	0.002	0.112	0	0	0	0	0	0	56	55
19	90	0.002	0.127	0	0	0	0	0	0	57	56
19	100	0.002	0.142	0	0	0	0	0	0	58	56
19	120	0.002	0.17	0	0	0	0	0	0	58	56
20	60	0.002	0.086	0	0	0	0	0	0	49	57
20	70	0.002	0.117	0	0	0	0	0	0	57	56
20	80	0.002	0.134	0	0	0	0	0	0	58	56
20	90	0.002	0.151	0	0	0	0	0	0	59	57
20	100	0.002	0.167	0	0	0	0	0	0	59	57
20	120	0.002	0.201	0	0	0	0	0	0	59	57
21	60	0.002	0.105	0	0	0	0	0	0	52	58
21	70	0.002	0.137	0	0	0	0	0	0	58	56
21	80	0.002	0.156	0	0	0	0	0	0	59	57
21	90	0.002	0.176	0	0	0	0	0	0	59	57
21	100	0.002	0.197	0	0	0	0	0	0	59	57
21	120	0.002	0.235	0	0	0	0	0	0	60	58
22	60	0.002	0.129	0	0	0	0	0	0	55	58
22	70	0.002	0.158	0	0	0	0	0	0	59	57
22	80	0.002	0.182	0	0	0	0	0	0	59	58
22	90	0.002	0.202	0	0	0	0	0	0	60	58
22	100	0.002	0.225	0	0	0	0	0	0	59	58

BHD	H/D	kapp.	s.NH.	1b	2a	2b	3a	3b	4+	%S	%D
22	120	0.002	0.269	0	0	0	0	0	0	60	58
23	60	0.002	0.15	0	0	0	0	0	0	57	57
23	70	0.002	0.18	0	0	0	0	0	0	59	57
23	80	0.002	0.202	0	0	0	0	0	0	58	56
23	90	0.002	0.215	0.014	0	0	0	0	0	59	57
23	100	0.002	0.231	0.022	0	0	0	0	0	59	57
23	120	0.002	0.271	0.037	0	0	0	0	0	60	58
24	50	0.002	0.131	0	0	0	0	0	0	52	59
24	60	0.002	0.172	0	0	0	0	0	0	58	56
24	70	0.002	0.191	0.01	0.004	0	0	0	0	59	57
24	80	0.002	0.177	0.052	0.009	0	0	0	0	61	59
24	90	0.002	0.196	0.071	0	0	0	0	0	61	59
24	100	0.002	0.216	0.078	0	0	0	0	0	60	59
24	120	0.002	0.251	0.097	0	0	0	0	0	60	58
25	50	0.002	0.135	0	0.016	0	0	0	0	53	59
25	60	0.002	0.194	0.003	0.001	0	0	0	0	58	57
25	70	0.002	0.14	0.064	0.034	0	0	0	0	60	59
25	80	0.002	0.181	0.082	0.007	0	0	0	0	61	59
25	90	0.002	0.201	0.094	0.007	0	0	0	0	61	59
25	100	0.002	0.225	0.105	0.007	0	0	0	0	62	60
25	120	0.002	0.204	0.161	0.03	0	0	0	0	61	59
26	50	0.002	0.116	0	0.061	0	0	0	0	55	58
26	60	0.002	0.123	0.043	0.06	0	0	0	0	60	58
26	70	0.002	0.075	0.084	0.108	0	0	0	0	61	59
26	80	0.002	0.136	0.096	0.07	0	0	0	0	61	59
26	90	0.002	0.182	0.113	0.042	0	0	0	0	61	59
26	100	0.002	0.112	0.163	0.104	0	0	0	0	62	60
26	120	0.002	0.141	0.214	0.097	0	0	0	0	62	60
27	50	0.002	0.153	0	0.049	0	0	0	0	57	58
27	60	0.002	0.06	0.075	0.123	0	0	0	0	61	60
27	70	0.002	0.067	0.098	0.134	0	0	0	0	61	60
27	80	0.002	0.127	0.114	0.096	0	0	0	0	61	60
27	90	0.002	0.099	0.162	0.12	0	0	0	0	62	60
27	100	0.002	0.089	0.199	0.137	0	0	0	0	62	60
27	120	0.002	0.099	0.273	0.136	0	0	0	0	63	61
28	50	0.002	0.101	0	0.132	0	0	0	0	59	59
28	60	0.002	0.055	0.087	0.145	0	0	0	0	61	60
28	70	0.002	0.056	0.115	0.163	0	0	0	0	61	60
28	80	0.002	0.061	0.153	0.165	0	0	0	0	62	60
28	90	0.002	0.068	0.202	0.158	0	0	0	0	62	61
28	100	0.002	0.074	0.233	0.165	0	0	0	0	62	61
28	120	0.002	0.086	0.322	0.159	0	0	0	0	63	61
29	50	0.002	0.1	0	0.16	0	0	0	0	60	59
29	60	0.002	0.068	0.088	0.164	0	0	0	0	62	60
29	70	0.002	0.054	0.129	0.187	0	0	0	0	62	60
29	80	0.002	0.059	0.201	0.166	0	0	0	0	63	61
29	90	0.002	0.066	0.233	0.176	0	0	0	0	63	61
29	100	0.002	0.071	0.293	0.167	0	0	0	0	63	62
29	120	0.002	0.082	0.376	0.172	0	0	0	0	63	61
30	40	0.002	0.036	0	0.18	0.002	0	0	0	56	61
30	50	0.002	0.136	0	0.151	0.01	0	0	0	61	60

BHD	H/D	kapp.	s.NH.	1b	2a	2b	3a	3b	4+	%S	%D
30	60	0.002	0.08	0.086	0.184	0	0	0	0	62	60
30	70	0.002	0.052	0.147	0.21	0	0	0	0	62	60
30	80	0.002	0.057	0.222	0.188	0	0	0	0	63	61
30	90	0.002	0.063	0.235	0.231	0	0	0	0	63	62
30	100	0.002	0.068	0.29	0.223	0	0	0	0	63	61
30	120	0.002	0.078	0.376	0.253	0	0	0	0	63	62
32	40	0.002	0.057	0	0.163	0.054	0	0	0	58	61
32	50	0.002	0.127	0	0.153	0.078	0	0	0	62	60
32	60	0.002	0.12	0.049	0.208	0.054	0	0	0	62	61
32	70	0.002	0.075	0.081	0.212	0.139	0	0	0	64	62
32	80	0.002	0.055	0.119	0.285	0.117	0	0	0	63	62
32	90	0.002	0.058	0.167	0.248	0.171	0	0	0	64	62
32	100	0.002	0.064	0.213	0.272	0.164	0	0	0	64	62
32	120	0.002	0.073	0.267	0.333	0.181	0	0	0	64	62
34	40	0.002	0.035	0	0.108	0.19	0	0	0	60	62
34	50	0.002	0.071	0	0.156	0.206	0	0	0	63	61
34	60	0.002	0.138	0.001	0.17	0.209	0	0	0	63	62
34	70	0.002	0.121	0.044	0.21	0.228	0	0	0	64	63
34	80	0.002	0.073	0.083	0.302	0.23	0	0	0	64	63
34	90	0.002	0.056	0.104	0.378	0.237	0	0	0	64	63
34	100	0.002	0.061	0.13	0.425	0.239	0	0	0	64	63
36	40	0.002	0.031	0	0.126	0.247	0.006	0	0	62	62
36	50	0.002	0.06	0	0.171	0.281	0	0	0	63	62
36	60	0.002	0.144	0	0.207	0.265	0	0	0	64	63
36	70	0.002	0.148	0.004	0.303	0.269	0	0	0	65	63
36	80	0.002	0.122	0.038	0.391	0.266	0.001	0	0	65	64
36	90	0.002	0.077	0.077	0.494	0.259	0.011	0	0	65	64
36	100	0.002	0.06	0.097	0.577	0.254	0.033	0	0	65	63
38	40	0.002	0.029	0	0.16	0.206	0.089	0	0	63	62
38	50	0.002	0.063	0	0.177	0.251	0.115	0	0	64	63
38	60	0.002	0.112	0	0.234	0.234	0.156	0	0	65	64
38	70	0.002	0.151	0	0.228	0.242	0.229	0	0	65	64
38	80	0.002	0.15	0.005	0.333	0.225	0.26	0	0	66	64
38	90	0.002	0.131	0.029	0.432	0.225	0.262	0	0	66	64
38	100	0.002	0.082	0.076	0.538	0.24	0.265	0	0	66	64
40	40	0.002	0.03	0	0.188	0.113	0.229	0	0	63	62
40	50	0.002	0.055	0	0.126	0.236	0.296	0	0	65	64
40	60	0.002	0.1	0	0.19	0.266	0.297	0	0	66	64
40	70	0.002	0.136	0	0.214	0.325	0.311	0	0	66	65
40	80	0.002	0.157	0	0.253	0.389	0.335	0	0	66	65
40	90	0.002	0.152	0.002	0.342	0.433	0.335	0	0	66	65
40	100	0.002	0.137	0.02	0.398	0.516	0.338	0	0	66	65
42	40	0.003	0.029	0	0.188	0.058	0.378	0	0	64	63
42	50	0.002	0.041	0	0.145	0.265	0.374	0	0	66	65
42	60	0.002	0.098	0	0.147	0.376	0.365	0.002	0	66	65
42	70	0.002	0.14	0	0.186	0.456	0.334	0.037	0	66	65
42	80	0.002	0.151	0	0.181	0.604	0.31	0.065	0	67	65
42	90	0.002	0.156	0	0.22	0.721	0.293	0.085	0	67	65
44	40	0.003	0.028	0	0.157	0.154	0.279	0.139	0	65	64
44	50	0.002	0.041	0	0.145	0.343	0.175	0.248	0	66	65
44	60	0.002	0.077	0	0.122	0.487	0.135	0.328	0	67	66

BHD	H/D	kapp.	s.NH.	1b	2a	2b	3a	3b	4+	%S	%D
44	70	0.002	0.126	0	0.179	0.523	0.153	0.351	0	67	66
44	80	0.002	0.151	0	0.183	0.635	0.168	0.374	0	67	66
44	90	0.002	0.153	0	0.175	0.756	0.226	0.386	0	67	66
46	40	0.002	0.028	0	0.147	0.192	0.187	0.312	0	66	65
46	50	0.002	0.034	0	0.153	0.263	0.256	0.381	0	67	66
46	60	0.002	0.071	0	0.105	0.4	0.308	0.425	0	67	66
46	70	0.002	0.11	0	0.138	0.496	0.326	0.445	0	68	66
46	80	0.002	0.144	0	0.179	0.584	0.358	0.456	0	68	66
48	40	0.002	0.029	0	0.15	0.083	0.242	0.491	0	67	66
48	50	0.002	0.033	0	0.148	0.237	0.331	0.477	0.015	68	67
48	60	0.002	0.058	0	0.115	0.339	0.485	0.309	0.101	68	67
48	70	0.002	0.105	0	0.101	0.423	0.602	0.359	0.138	68	67
48	80	0.002	0.134	0	0.172	0.46	0.697	0.305	0.194	68	67
50	40	0.002	0.029	0	0.166	0.041	0.356	0.259	0.278	67	66
50	50	0.002	0.032	0	0.154	0.256	0.422	0.121	0.418	68	67
50	60	0.002	0.051	0	0.118	0.257	0.713	0.067	0.475	68	67
50	70	0.002	0.102	0	0.073	0.433	0.777	0.082	0.497	69	67
50	80	0.002	0.126	0	0.14	0.363	0.923	0.151	0.522	69	68

Appendix 1.5 *Larix decidua*, single tree assortment tables

BHD	H/D	kapp.	s.NH.	1b	2a	2b	3a	3b	4+	%S	%D
10	120	0.002	0.011	0	0	0	0	0	0	26	43
11	120	0.002	0.02	0	0	0	0	0	0	34	43
12	100	0.002	0.023	0	0	0	0	0	0	35	51
12	120	0.002	0.033	0	0	0	0	0	0	41	46
13	100	0.002	0.035	0	0	0	0	0	0	42	51
13	120	0.002	0.046	0	0	0	0	0	0	46	49
14	90	0.002	0.039	0	0	0	0	0	0	42	53
14	100	0.002	0.048	0	0	0	0	0	0	47	50
14	120	0.002	0.061	0	0	0	0	0	0	48	51
15	80	0.002	0.043	0	0	0	0	0	0	43	56
15	90	0.002	0.055	0	0	0	0	0	0	48	52
15	100	0.002	0.063	0	0	0	0	0	0	50	52
15	120	0.002	0.078	0	0	0	0	0	0	51	53
16	80	0.002	0.057	0	0	0	0	0	0	47	55
16	90	0.002	0.071	0	0	0	0	0	0	52	54
16	100	0.002	0.081	0	0	0	0	0	0	53	55
16	120	0.002	0.097	0	0	0	0	0	0	52	54
17	70	0.002	0.06	0	0	0	0	0	0	48	58
17	80	0.002	0.076	0	0	0	0	0	0	52	55
17	90	0.002	0.089	0	0	0	0	0	0	54	55
17	100	0.002	0.1	0	0	0	0	0	0	54	56
17	120	0.002	0.124	0	0	0	0	0	0	55	56
18	70	0.002	0.076	0	0	0	0	0	0	50	58
18	80	0.002	0.094	0	0	0	0	0	0	54	56
18	90	0.002	0.106	0	0	0	0	0	0	54	56
18	100	0.002	0.12	0	0	0	0	0	0	55	56
18	120	0.002	0.146	0	0	0	0	0	0	56	57
19	70	0.002	0.092	0	0	0	0	0	0	52	56
19	80	0.002	0.111	0	0	0	0	0	0	55	56
19	90	0.002	0.128	0	0	0	0	0	0	55	57
19	100	0.002	0.144	0	0	0	0	0	0	56	57
19	120	0.002	0.175	0	0	0	0	0	0	56	58
20	60	0.002	0.089	0	0	0	0	0	0	51	59
20	70	0.002	0.112	0	0	0	0	0	0	55	56
20	80	0.002	0.131	0	0	0	0	0	0	56	57
20	90	0.002	0.151	0	0	0	0	0	0	57	58
20	100	0.002	0.171	0	0	0	0	0	0	57	58
20	120	0.002	0.206	0	0	0	0	0	0	57	58
21	60	0.002	0.105	0	0	0	0	0	0	53	59
21	70	0.002	0.133	0	0	0	0	0	0	56	57
21	80	0.002	0.153	0	0	0	0	0	0	57	58
21	90	0.002	0.178	0	0	0	0	0	0	57	58
21	100	0.002	0.202	0	0	0	0	0	0	58	59
21	120	0.002	0.244	0	0	0	0	0	0	58	59
22	60	0.002	0.126	0	0	0	0	0	0	55	58
22	70	0.002	0.154	0	0	0	0	0	0	57	58
22	80	0.002	0.182	0	0	0	0	0	0	58	59
22	90	0.002	0.203	0	0	0	0	0	0	58	59
22	100	0.002	0.223	0.002	0	0	0	0	0	57	58

BHD	H/D	kapp.	s.NH.	1b	2a	2b	3a	3b	4+	%S	%D
22	120	0.002	0.254	0.021	0	0	0	0	0	58	58
23	60	0.002	0.147	0	0	0	0	0	0	56	58
23	70	0.002	0.176	0	0	0	0	0	0	57	58
23	80	0.002	0.199	0.006	0	0	0	0	0	58	58
23	90	0.002	0.197	0.038	0	0	0	0	0	58	59
23	100	0.002	0.2	0.067	0	0	0	0	0	59	60
23	120	0.002	0.236	0.083	0	0	0	0	0	59	59
24	50	0.002	0.134	0	0	0	0	0	0	56	61
24	60	0.002	0.168	0	0	0	0	0	0	57	58
24	70	0.002	0.19	0.003	0.003	0	0	0	0	56	57
24	80	0.002	0.156	0.055	0.026	0	0	0	0	59	60
24	90	0.002	0.193	0.081	0.001	0	0	0	0	60	61
24	100	0.002	0.215	0.092	0	0	0	0	0	60	61
24	120	0.002	0.232	0.134	0	0	0	0	0	59	60
25	50	0.002	0.117	0	0.035	0	0	0	0	57	61
25	60	0.002	0.187	0	0	0	0	0	0	56	57
25	70	0.002	0.137	0.046	0.048	0	0	0	0	59	59
25	80	0.002	0.135	0.082	0.054	0	0	0	0	59	60
25	90	0.002	0.169	0.097	0.041	0	0	0	0	60	60
25	100	0.002	0.205	0.116	0.021	0	0	0	0	60	60
25	120	0.002	0.158	0.193	0.072	0	0	0	0	61	61
26	50	0.002	0.107	0	0.065	0	0	0	0	57	59
26	60	0.002	0.178	0.012	0.022	0	0	0	0	57	58
26	70	0.002	0.058	0.083	0.123	0	0	0	0	60	60
26	80	0.002	0.103	0.1	0.101	0	0	0	0	60	60
26	90	0.002	0.158	0.119	0.069	0	0	0	0	60	60
26	100	0.002	0.096	0.172	0.122	0	0	0	0	61	61
26	120	0.002	0.112	0.244	0.122	0	0	0	0	61	62
27	50	0.003	0.119	0	0.073	0	0	0	0	57	59
27	60	0.002	0.13	0.035	0.077	0	0	0	0	59	59
27	70	0.002	0.055	0.096	0.143	0	0	0	0	60	60
27	80	0.002	0.07	0.113	0.157	0	0	0	0	60	60
27	90	0.002	0.069	0.164	0.155	0	0	0	0	61	61
27	100	0.002	0.075	0.211	0.153	0	0	0	0	61	61
27	120	0.002	0.085	0.294	0.152	0	0	0	0	61	61
28	50	0.002	0.068	0	0.147	0	0	0	0	57	58
28	60	0.002	0.094	0.045	0.141	0	0	0	0	60	61
28	70	0.002	0.055	0.11	0.167	0	0	0	0	60	61
28	80	0.002	0.061	0.142	0.179	0	0	0	0	61	61
28	90	0.002	0.067	0.211	0.162	0	0	0	0	61	62
28	100	0.002	0.072	0.242	0.173	0	0	0	0	61	62
28	120	0.002	0.081	0.351	0.164	0	0	0	0	62	62
29	50	0.002	0.066	0	0.174	0	0	0	0	58	58
29	60	0.002	0.106	0.043	0.16	0	0	0	0	61	61
29	70	0.002	0.054	0.124	0.186	0	0	0	0	60	61
29	80	0.002	0.059	0.18	0.189	0	0	0	0	61	62
29	90	0.002	0.065	0.218	0.204	0	0	0	0	61	62
29	100	0.002	0.069	0.23	0.249	0	0	0	0	62	62
29	120	0.002	0.078	0.331	0.254	0	0	0	0	62	62
30	40	0.002	0.033	0	0.184	0	0	0	0	61	62
30	50	0.002	0.093	0	0.151	0.027	0	0	0	59	60

BHD	H/D	kapp.	s.NH.	1b	2a	2b	3a	3b	4+	%S	%D
30	60	0.002	0.13	0.029	0.182	0	0	0	0	60	61
30	70	0.002	0.057	0.127	0.221	0	0	0	0	61	61
30	80	0.002	0.058	0.102	0.321	0	0	0	0	62	62
30	90	0.002	0.063	0.159	0.322	0	0	0	0	62	62
30	100	0.002	0.067	0.213	0.325	0	0	0	0	62	63
30	120	0.002	0.075	0.275	0.379	0.011	0	0	0	62	62
32	40	0.002	0.035	0	0.206	0.018	0	0	0	61	61
32	50	0.002	0.129	0	0.081	0.126	0	0	0	60	61
32	60	0.002	0.155	0.011	0.185	0.066	0	0	0	61	61
32	70	0.002	0.108	0.055	0.179	0.157	0	0	0	62	62
32	80	0.002	0.066	0.101	0.271	0.144	0	0	0	62	62
32	90	0.002	0.059	0.104	0.299	0.195	0	0	0	62	63
32	100	0.002	0.064	0.138	0.35	0.187	0	0	0	63	63
32	120	0.002	0.071	0.198	0.42	0.208	0	0	0	63	63
34	40	0.002	0.048	0	0.124	0.14	0	0	0	61	61
34	50	0.002	0.094	0	0.084	0.224	0	0	0	61	61
34	60	0.002	0.133	0	0.149	0.215	0	0	0	62	62
34	70	0.002	0.149	0.017	0.186	0.25	0	0	0	63	63
34	80	0.002	0.114	0.046	0.289	0.243	0	0	0	63	63
34	90	0.002	0.068	0.093	0.383	0.249	0	0	0	63	63
34	100	0.002	0.061	0.096	0.479	0.246	0	0	0	63	63
36	40	0.002	0.038	0	0.108	0.193	0.026	0	0	60	60
36	50	0.002	0.063	0	0.13	0.281	0	0	0	61	61
36	60	0.002	0.129	0	0.19	0.269	0.001	0	0	62	63
36	70	0.002	0.146	0	0.26	0.282	0.023	0	0	63	63
36	80	0.002	0.149	0.014	0.332	0.29	0.041	0	0	63	64
36	90	0.002	0.118	0.039	0.426	0.299	0.055	0	0	64	64
36	100	0.002	0.068	0.091	0.507	0.294	0.098	0	0	64	64
38	40	0.002	0.032	0	0.122	0.149	0.121	0	0	61	61
38	50	0.002	0.067	0	0.16	0.233	0.101	0	0	62	62
38	60	0.002	0.127	0	0.199	0.198	0.19	0	0	63	63
38	70	0.002	0.153	0	0.186	0.247	0.254	0	0	64	64
38	80	0.002	0.157	0.001	0.265	0.274	0.272	0	0	64	64
38	90	0.002	0.152	0.01	0.34	0.318	0.273	0	0	64	64
38	100	0.002	0.121	0.036	0.411	0.374	0.295	0	0	64	64
40	40	0.002	0.032	0	0.152	0.059	0.249	0	0	61	61
40	50	0.002	0.064	0	0.134	0.21	0.24	0	0	62	62
40	60	0.002	0.11	0	0.14	0.246	0.317	0	0	63	63
40	70	0.002	0.149	0	0.201	0.28	0.341	0	0	64	64
40	80	0.002	0.158	0	0.181	0.448	0.343	0	0	64	64
40	90	0.002	0.158	0	0.269	0.516	0.34	0	0	64	64
40	100	0.002	0.154	0.006	0.313	0.621	0.346	0	0	64	64
42	40	0.002	0.032	0	0.176	0.01	0.348	0	0	61	61
42	50	0.002	0.063	0	0.12	0.21	0.371	0	0	63	63
42	60	0.002	0.112	0	0.139	0.317	0.355	0.021	0	64	64
42	70	0.002	0.147	0	0.176	0.415	0.322	0.06	0	64	64
42	80	0.002	0.157	0	0.183	0.586	0.292	0.09	0	64	65
42	90	0.002	0.157	0	0.174	0.75	0.261	0.142	0	65	65
44	40	0.002	0.034	0	0.189	0.022	0.342	0.071	0	62	62
44	50	0.002	0.06	0	0.123	0.279	0.197	0.215	0	63	64
44	60	0.002	0.107	0	0.092	0.456	0.089	0.349	0	64	64

BHD	H/D	kapp.	s.NH.	1b	2a	2b	3a	3b	4+	%S	%D
44	70	0.002	0.145	0	0.171	0.397	0.221	0.357	0	64	65
44	80	0.002	0.151	0	0.177	0.511	0.292	0.371	0	65	65
44	90	0.002	0.155	0	0.172	0.682	0.3	0.396	0	65	65
46	40	0.002	0.032	0	0.174	0.095	0.219	0.231	0	62	62
46	50	0.002	0.056	0	0.13	0.273	0.168	0.361	0	64	64
46	60	0.002	0.1	0	0.094	0.338	0.288	0.421	0	65	65
46	70	0.002	0.135	0	0.145	0.39	0.354	0.451	0	65	65
46	80	0.002	0.148	0	0.187	0.474	0.424	0.457	0	65	65
48	40	0.002	0.032	0	0.158	0.164	0.107	0.404	0	63	63
48	50	0.002	0.055	0	0.132	0.223	0.222	0.483	0.005	64	64
48	60	0.002	0.091	0	0.086	0.354	0.369	0.431	0.063	65	65
48	70	0.002	0.132	0	0.125	0.348	0.552	0.388	0.113	65	65
48	80	0.002	0.149	0	0.169	0.392	0.712	0.293	0.211	65	65
50	40	0.002	0.031	0	0.163	0.087	0.151	0.35	0.179	63	63
50	50	0.002	0.053	0	0.127	0.234	0.324	0.166	0.366	65	65
50	60	0.002	0.102	0	0.062	0.269	0.607	0.09	0.448	65	65
50	70	0.002	0.124	0	0.103	0.378	0.696	0.077	0.491	65	65
50	80	0.002	0.15	0	0.164	0.3	0.849	0.197	0.5	65	66

Appendix 1.6 *Abies alba*, single tree assortment tables

BHD	H/D	kapp.	s.NH.	1b	2a	2b	3a	3b	4+	%S	%D
10	120	0.002	0.015	0	0	0	0	0	0	30	58
11	120	0.002	0.023	0	0	0	0	0	0	34	58
12	100	0.002	0.029	0	0	0	0	0	0	39	64
12	120	0.002	0.037	0	0	0	0	0	0	40	57
13	100	0.002	0.042	0	0	0	0	0	0	43	63
13	120	0.002	0.056	0	0	0	0	0	0	48	63
14	90	0.002	0.048	0	0	0	0	0	0	45	65
14	100	0.002	0.059	0	0	0	0	0	0	49	64
14	120	0.002	0.077	0	0	0	0	0	0	53	65
15	80	0.002	0.052	0	0	0	0	0	0	46	68
15	90	0.002	0.068	0	0	0	0	0	0	51	66
15	100	0.002	0.079	0	0	0	0	0	0	54	67
15	120	0.002	0.102	0	0	0	0	0	0	57	67
16	80	0.002	0.071	0	0	0	0	0	0	50	68
16	90	0.002	0.088	0	0	0	0	0	0	55	68
16	100	0.002	0.102	0	0	0	0	0	0	57	68
16	120	0.002	0.13	0	0	0	0	0	0	60	69
17	70	0.002	0.073	0	0	0	0	0	0	51	70
17	80	0.002	0.093	0	0	0	0	0	0	55	69
17	90	0.002	0.11	0	0	0	0	0	0	58	69
17	100	0.002	0.128	0	0	0	0	0	0	60	70
17	120	0.002	0.163	0	0	0	0	0	0	62	70
18	70	0.002	0.091	0	0	0	0	0	0	53	70
18	80	0.002	0.117	0	0	0	0	0	0	58	70
18	90	0.002	0.136	0	0	0	0	0	0	60	70
18	100	0.002	0.157	0	0	0	0	0	0	62	71
18	120	0.002	0.191	0.003	0	0	0	0	0	64	71
19	70	0.002	0.115	0	0	0	0	0	0	57	71
19	80	0.002	0.141	0	0	0	0	0	0	61	71
19	90	0.002	0.162	0.003	0	0	0	0	0	62	71
19	100	0.002	0.139	0.05	0	0	0	0	0	64	72
19	120	0.002	0.145	0.09	0	0	0	0	0	65	72
20	60	0.002	0.107	0	0	0	0	0	0	54	71
20	70	0.002	0.14	0	0	0	0	0	0	60	71
20	80	0.002	0.17	0	0	0	0	0	0	63	72
20	90	0.002	0.149	0.05	0	0	0	0	0	65	73
20	100	0.002	0.112	0.115	0	0	0	0	0	66	73
20	120	0.002	0.135	0.14	0	0	0	0	0	66	72
21	60	0.002	0.128	0	0	0	0	0	0	57	72
21	70	0.002	0.167	0	0	0	0	0	0	62	72
21	80	0.002	0.186	0.01	0	0	0	0	0	63	71
21	90	0.002	0.116	0.117	0	0	0	0	0	65	73
21	100	0.002	0.103	0.164	0	0	0	0	0	67	74
21	120	0.002	0.12	0.214	0	0	0	0	0	68	74
22	60	0.002	0.151	0	0	0	0	0	0	59	72
22	70	0.002	0.196	0	0	0	0	0	0	63	72
22	80	0.002	0.183	0.036	0.013	0	0	0	0	65	73
22	90	0.002	0.131	0.135	0.004	0	0	0	0	66	73
22	100	0.002	0.094	0.215	0.004	0	0	0	0	68	74

BHD	H/D	kapp.	s.NH.	1b	2a	2b	3a	3b	4+	%S	%D
22	120	0.002	0.107	0.266	0.011	0	0	0	0	69	74
23	60	0.002	0.179	0	0.002	0	0	0	0	61	72
23	70	0.002	0.18	0.018	0.027	0	0	0	0	64	72
23	80	0.002	0.088	0.081	0.101	0	0	0	0	66	73
23	90	0.002	0.084	0.15	0.077	0	0	0	0	67	73
23	100	0.002	0.085	0.19	0.081	0	0	0	0	68	74
23	120	0.002	0.095	0.224	0.121	0	0	0	0	70	75
24	50	0.002	0.061	0	0.099	0	0	0	0	59	73
24	60	0.002	0.203	0	0.011	0	0	0	0	64	72
24	70	0.002	0.095	0.059	0.11	0	0	0	0	66	74
24	80	0.002	0.068	0.099	0.144	0	0	0	0	68	74
24	90	0.002	0.072	0.126	0.164	0	0	0	0	69	75
24	100	0.002	0.075	0.187	0.145	0	0	0	0	69	74
24	120	0.002	0.087	0.268	0.151	0	0	0	0	71	75
25	50	0.002	0.048	0	0.136	0	0	0	0	61	74
25	60	0.002	0.143	0	0.103	0	0	0	0	65	73
25	70	0.002	0.068	0.085	0.149	0	0	0	0	67	74
25	80	0.002	0.064	0.115	0.179	0	0	0	0	69	74
25	90	0.002	0.068	0.179	0.164	0	0	0	0	69	75
25	100	0.002	0.071	0.227	0.165	0	0	0	0	70	75
25	120	0.002	0.079	0.261	0.231	0	0	0	0	71	75
26	50	0.002	0.047	0	0.165	0	0	0	0	62	73
26	60	0.002	0.128	0.001	0.151	0	0	0	0	66	74
26	70	0.002	0.061	0.107	0.176	0	0	0	0	68	75
26	80	0.002	0.059	0.144	0.2	0	0	0	0	69	75
26	90	0.002	0.064	0.182	0.221	0	0	0	0	70	75
26	100	0.002	0.067	0.197	0.262	0	0	0	0	71	75
26	120	0.002	0.075	0.25	0.323	0	0	0	0	72	75
27	50	0.002	0.06	0	0.18	0	0	0	0	63	73
27	60	0.002	0.149	0.002	0.171	0	0	0	0	68	75
27	70	0.002	0.063	0.115	0.206	0	0	0	0	69	75
27	80	0.002	0.055	0.106	0.293	0	0	0	0	70	75
27	90	0.002	0.06	0.118	0.348	0	0	0	0	71	76
27	100	0.002	0.064	0.201	0.328	0	0	0	0	72	76
27	120	0.002	0.071	0.215	0.443	0	0	0	0	72	76
28	50	0.003	0.097	0	0.149	0.032	0	0	0	65	74
28	60	0.002	0.162	0.001	0.181	0.016	0	0	0	68	75
28	70	0.002	0.06	0.112	0.219	0.049	0	0	0	70	76
28	80	0.002	0.054	0.102	0.279	0.079	0	0	0	71	76
28	90	0.002	0.057	0.13	0.315	0.087	0	0	0	72	76
28	100	0.002	0.061	0.167	0.308	0.126	0	0	0	72	76
28	120	0.002	0.068	0.209	0.392	0.143	0	0	0	73	76
29	50	0.002	0.127	0	0.057	0.131	0	0	0	67	74
29	60	0.002	0.173	0	0.143	0.087	0	0	0	69	75
29	70	0.002	0.085	0.074	0.164	0.167	0	0	0	71	76
29	80	0.002	0.052	0.113	0.204	0.198	0	0	0	71	76
29	90	0.002	0.055	0.099	0.291	0.208	0	0	0	72	76
29	100	0.002	0.059	0.119	0.338	0.22	0	0	0	73	76
29	120	0.002	0.066	0.189	0.436	0.219	0	0	0	73	76
30	40	0.002	0.042	0	0.197	0.021	0	0	0	65	75
30	50	0.002	0.147	0	0.002	0.206	0	0	0	68	75

BHD	H/D	kapp.	s.NH.	1b	2a	2b	3a	3b	4+	%S	%D
30	60	0.003	0.171	0	0.075	0.199	0	0	0	70	76
30	70	0.002	0.125	0.028	0.162	0.227	0	0	0	71	76
30	80	0.002	0.062	0.102	0.228	0.244	0	0	0	72	76
30	90	0.002	0.053	0.101	0.339	0.233	0	0	0	72	76
30	100	0.002	0.056	0.1	0.431	0.234	0	0	0	73	77
30	120	0.002	0.063	0.164	0.522	0.26	0	0	0	74	76
32	40	0.002	0.065	0	0.074	0.182	0	0	0	66	75
32	50	0.002	0.11	0	0.066	0.259	0	0	0	69	75
32	60	0.002	0.137	0	0.151	0.267	0	0	0	71	76
32	70	0.003	0.146	0.008	0.214	0.302	0	0	0	73	77
32	80	0.002	0.13	0.024	0.258	0.366	0	0	0	73	77
32	90	0.002	0.084	0.073	0.307	0.423	0	0	0	74	77
32	100	0.002	0.061	0.095	0.359	0.484	0	0	0	74	77
32	120	0.002	0.06	0.097	0.515	0.546	0	0	0	74	77
34	40	0.002	0.052	0	0.057	0.241	0.039	0	0	68	75
34	50	0.002	0.077	0	0.137	0.256	0.062	0	0	70	76
34	60	0.002	0.135	0	0.191	0.178	0.158	0	0	72	77
34	70	0.002	0.143	0	0.177	0.278	0.208	0	0	73	77
34	80	0.002	0.152	0.002	0.205	0.342	0.232	0	0	74	77
34	90	0.002	0.142	0.014	0.284	0.366	0.264	0	0	74	77
34	100	0.002	0.112	0.042	0.33	0.441	0.275	0	0	75	77
36	40	0.002	0.04	0	0.12	0.086	0.224	0	0	69	76
36	50	0.002	0.073	0	0.119	0.179	0.261	0	0	72	77
36	60	0.002	0.099	0	0.136	0.215	0.343	0	0	73	77
36	70	0.002	0.144	0	0.192	0.281	0.337	0	0	74	77
36	80	0.002	0.148	0	0.18	0.449	0.339	0	0	74	78
36	90	0.002	0.154	0	0.216	0.52	0.375	0	0	75	78
36	100	0.002	0.152	0.003	0.274	0.574	0.416	0	0	75	78
38	40	0.003	0.032	0	0.164	0.006	0.356	0	0	70	76
38	50	0.002	0.051	0	0.129	0.197	0.375	0	0	73	77
38	60	0.003	0.088	0	0.145	0.321	0.374	0.017	0	74	78
38	70	0.002	0.12	0	0.176	0.346	0.441	0.046	0	75	78
38	80	0.002	0.145	0	0.194	0.361	0.531	0.083	0	75	78
38	90	0.002	0.153	0	0.175	0.486	0.572	0.112	0	76	78
38	100	0.002	0.154	0	0.196	0.624	0.599	0.1	0	76	78
40	40	0.003	0.031	0	0.175	0.037	0.33	0.088	0	71	76
40	50	0.003	0.042	0	0.14	0.272	0.191	0.245	0	74	78
40	60	0.002	0.081	0	0.092	0.291	0.259	0.379	0	75	78
40	70	0.002	0.111	0	0.157	0.333	0.336	0.381	0	75	78
40	80	0.002	0.137	0	0.185	0.374	0.428	0.403	0	76	78
40	90	0.002	0.148	0	0.186	0.468	0.523	0.418	0	76	78
40	100	0.002	0.153	0	0.176	0.547	0.663	0.411	0	76	78
42	40	0.002	0.03	0	0.181	0.104	0.16	0.304	0	72	77
42	50	0.003	0.035	0	0.152	0.246	0.138	0.45	0	74	78
42	60	0.002	0.057	0	0.116	0.279	0.356	0.462	0	75	78
42	70	0.002	0.089	0	0.109	0.393	0.46	0.458	0	76	78
42	80	0.002	0.126	0	0.172	0.318	0.662	0.49	0	76	78
42	90	0.002	0.146	0	0.179	0.424	0.673	0.602	0	76	78
44	40	0.003	0.028	0	0.174	0.134	0.067	0.488	0	73	78
44	50	0.003	0.031	0	0.157	0.207	0.277	0.414	0.098	75	78
44	60	0.003	0.053	0	0.123	0.266	0.454	0.41	0.172	76	79

BHD	H/D	kapp.	s.NH.	1b	2a	2b	3a	3b	4+	%S	%D
44	70	0.002	0.082	0	0.088	0.357	0.44	0.552	0.229	76	79
44	80	0.002	0.113	0	0.143	0.34	0.55	0.632	0.254	77	79
44	90	0.002	0.141	0	0.163	0.337	0.731	0.669	0.269	77	79
46	40	0.002	0.028	0	0.152	0.073	0.227	0.235	0.316	74	78
46	50	0.003	0.03	0	0.159	0.22	0.321	0.17	0.447	75	79
46	60	0.003	0.044	0	0.129	0.249	0.356	0.378	0.518	76	79
46	70	0.002	0.071	0	0.094	0.288	0.548	0.455	0.547	77	79
46	80	0.002	0.108	0	0.094	0.385	0.578	0.598	0.55	77	79
48	40	0.002	0.027	0	0.169	0.038	0.317	0.091	0.537	75	78
48	50	0.003	0.03	0	0.155	0.232	0.195	0.323	0.605	76	79
48	60	0.002	0.036	0	0.135	0.247	0.385	0.507	0.603	77	79
48	70	0.002	0.067	0	0.099	0.24	0.553	0.661	0.632	77	79
48	80	0.002	0.089	0	0.091	0.346	0.56	0.788	0.752	77	79
50	40	0.003	0.026	0	0.163	0.044	0.338	0.097	0.646	75	79
50	50	0.002	0.03	0	0.16	0.155	0.269	0.476	0.648	76	79
50	60	0.002	0.033	0	0.137	0.254	0.363	0.534	0.831	77	79
50	70	0.002	0.054	0	0.114	0.235	0.503	0.577	1.087	78	79
50	80	0.002	0.081	0	0.084	0.315	0.546	0.74	1.19	78	79

Appendix 2

Questionnaires on game management

Unfortunately, it doesn't exist a clear and homogeneous European game species market. Therefore, in order to measure the economic and social importance of hunting ecosystems services in each case study area we have collected information about local fauna population and their management (how raising and harvesting activities are organized and marketed) through a questionnaire. So data to achieve hunting ecosystem services objectives in the ARANGE project is collected by questionnaires and provided by the managers in charge of game management in every study area: Vercors Massif (Western Alps, France), National Forest Centre Zvolen (Rodophe Mountains, Slovak), Snežnik (Dinaric Mountains, Slovenian), Valsaín (Iberian mountains, Spain), and Vilhelmina (Scandinavian mountains, Sweden).

The questionnaire is designed to quantify (physically and economically) the relevance of hunting within mountain systems. The main structure of the questionnaire is: (1) Background. General questions; (2) Quantities and prices of inputs used to raise game animals; (3) Quantities and prices of inputs used to hunt game animals (recreational); (4) Results of harvest in the last 3 years; (5) Identification and quantification of main hunting-forest conflicts; and (6) Additional questions about owned vehicles, equipment and infrastructures related to raising game animals, hunting and avoiding hunting-forest conflicts.

We established a dead-line to fill in the questionnaire up to the 15th of March of 2013. At that time Slovenia, Slovakia and Spain did answer the questionnaire. However, during the workshop at Ljubljana in April 2013, it was agreed that Sweden and France would answer the questionnaire (France sent it at the end of May 2013 and we still working with Sweden). Also, at the workshop, we did some feed-back to the answers received at that time and got a more realistic picture of the conflicts between silvicultural practices and game management in every case study area. Moreover, we detected the need to enlarge the questionnaire with five additional questions related to estimated density populations and their impact on forest.

In the case of Spain, fieldwork was carried out to define a relationship between stand-forest characteristics and pasture (in terms of quantity and quality of the pasture). So an ulterior habitat characterization at the stand level would takes into account diet sources could be defined (see Anexo 2). To achieve this objective a sample of 60 plots was made in Valsaín pine forest taking tree and pasture measurements. Data were analysed and different generalized lineal models were fitted using R 2.3.1 (R Development Core Team, 2006; following Crawley, 2007).

An important question to consider is the difficulty of the link function transferability. We don't think that the same functions could be transfer from one case study area to another. We think that the best way to compare conflicts and game management importance between countries might be derived from the economic value of hunting. Therefore we might use all the information collected in the questionnaire to be able to put the game harvest potentiality and the silviculture-hunting conflicts into economic units.

Appendix 3

Game management scenario in every case study

Game management scenarios and game-forest management conflicts are described in Table A3.1, A3.2, A3.3, and A3.4.

Table A3.1 Description of the activities involved in game species raising activities. Game management conflicts detected in the questionnaires are included. (CSi: Case study "i")

Case study	**Type of landowner**	**S (ha)**	**Main hunting aim**	**Main raising activities**	**Forest - Game management conflicts detected**
Dinaric Mountains (Slovenia)	Private and public (public administrator)	5000	Big game	Surveillance Feeding Cropping	Browsing
Valsaín (Spain)	Public	10668	Small game	Surveillance Predator control Administrative work	No browsing conflict detected.
Vilhelmina (Sweden)[1]	Private and public	300000	Big game	Census Predator control Salt Administrative work	Browsing
National Forest Centre Zvolen (Slovakia)	Private	CS1: 3769 CS2: 4153 CS3: 3401 CS4: 5451	Big game	Surveillance Census Health management Feeding Predator control Culling Administrative work Crops	Browsing
Vercors Massif (France)	Private and public	CS1: 6700 CS2: 3300	Big game	Surveillance Census Restocking	Browsing

				Feeding Other (clearing)		

[1]Data here applies only to moose, the most important species in Vilhelmina.

Table A3.2 Description of the activities involved in harvesting activities. Harvest figures correspond to the average of three consecutive years (bg: big game; sg: small game; CSi: case study "i")

Case study	**S (ha)**	**Main species**	**Main hunting modalities**	**Main harvesting activities**	**Average N recreational animals**	**Average N hunting journals**
Dinaric Mountains (Slovenia)	5000	Wild boar, Red deer, Roe deer	Stalking Stand hunting Driven hunt	Planning and organizing Feeding Fixing hunting stands Cleaning hunting roads Surveillance, hunter assistance Driving game animals	89 bg	450
Valsaín (Spain)	10668	Wild boar Rabbit Partridge Hare Woodcock dove Carrion crow Fox	Stalking Stand hunting Big game driven hunt	Planning and organizing Surveillance,hunter assistance	14 bg 1257 sg	2100
Vilhelmina (Sweden)[1]	350000	Moose Hare Brown bear Lynx bonasa bonassia Tetrao tetrix Tetrao urogallus Lagopus muta Lagopus lagopus	Stalking Driven hunt Culling	Planning and organizing Driving game animals Death animal's removal	500 moose	2380
National Forest Centre Zvolen	CS1: 3769 CS2: 4153	Red deer Roe deer	Stalking Stand hunting	Planning and organizing Feeding	CS1: 1.3 bg CS2: 1.3 bg	CS1: 20 CS2: 20

(Slovakia)[2]	CS3: 3401 CS4: 5451	Wild boar	Driven hunt Culling	Fixing hunting stands Surveillance, hunter assistance Driving game animals Death animal's removal Veterinary control Catering and accommodation	CS3: 2 bg CS4: 10 bg	CS3: 50 CS4: 100
Vercors Massif (France)[3]	CS1: 6700 CS2: 3300	Chamois Mouflon Roe deer Red deer Wild boar Small game	Stalking Driven hunt	Planning and organizing	CS1:129 bg CS2:76 bg	CS1:900 CS2:620

[1]Data here applies only to moose, the most important species in Vilhelmina.

Table A3.3 Weighted average of net private revenues (NPR) per hectare and net social revenues (NSR) per hectare, per animal harvested and per hunting journey in every case study area (CSi: case study "i")

Case study	**S** (ha)	**Raising cost** (€/ha)	**Harvesting cost** (€/ha)	**Game-forest conflict cost** (€/ha)	**Total revenues** (€/ha)	**NPR per hectare** (€/ha)	**NSR per hectare** (€/ha)	**NSR per animal** (€/recreational animal)	**NSR per journey** (€/hunting journey)
Dinaric Mountains (Slovenia)	5000	4.47	1.54	0.12**	4.31	-1.70	-1.82	-102.4	-20.3
Valsaín (Spain)	10668	1.33	0.04	0.00	0.56	-0.48	-0.48	-4.1 *	-2.4
Vilhelmina (Sweden)[1]	300000				1.50				
National Forest Centre Zvolen (Slovakia)	CS1: 3769	2.80	1.14	2.70	1.72	-2.22	-4.92	-14264	-927.2
	CS2: 4153	4.21	0.80	1.75	0.76	-4.25	-6.00	-19167	-1245.9
	CS3: 3401	2.41	0.21	1.52	2.85	+0.23	-1.29	-2194	-87.7
	CS4: 5451	2.09	0.40	0.71	1.74	-0.75	-1.46	-796	-79.6
	Weighted average	*2.84*	*0.63*	*1.58*	*1.72*	*-1.75*	*-3.33*	*-3825.8*	*-294.0*
Vercors Massif (France)	CS1: 6700	1.04	0.00**	0.15	0.04	-1.00	-1.15	-59.7	-8.56
	CS2: 3300	0.21	0.00**	0.03	0.24	+0.03	0.00	0.00	0.00
	Weighted average	*0.77*	*0.00*	*0.11*	*0.11*	*-0.66*	*-0.77*	*-37.6*	-5.1

[1]Data here applies only to moose, the most important species in Vilhelmina.
*Only small game animals are considered
** All the cost is assumed by the hunters without an opportunity cost

Appendix 4

Effects of tree density over natural pasture in Pinus sylvestris L. forests in the Sierra de Guadarrama: the study case of the M.U.P. nº 2 "Pinar" of Valsaín

In the case of Spain, fieldwork was carried out to define a relationship between stand-forest characteristics and pasture (in terms of quantity and quality of the pasture). So an ulterior habitat characterization at the stand level would takes into account diet sources could be defined (see Anexo 2). To achieve this objective a sample of 60 plots was made in Valsaín pine forest taking tree and pasture measurements. Data were analysed and different generalized lineal models were fitted using R 2.3.1 (R Development Core Team, 2006; following Crawley, 2007).

A summary of the main relationships found between pine stand-forest characteristics and pasture, which in turn might change game species quality habitat in a tree forest context:

(1) It was not possible to establish a model for legume cover (a proxy on pasture quality) due its absence in the sample. We found that the major limitation on pastures of this pine forest was the presence of poor soils combined with a low grazing pressure. As known, grazing results in better soil (organic carbon and nitrogen content) compared to ungrazed soils. That is because grazers trample the plant material into small pieces and add fertilization, and this helps to recycle carbon and nitrogen into the soil.

(2) Grass cover (and therefore quantity of grass) depends on tree density at Valsaín: Grass cover (%) = 50,09804 – 0,1909•N (with N = number of trees per hectare, R2 = 0,135, and adjusted R2 = 0,120). Although the prediction value is very low, we found a significant relationship. In general, more grass cover in a tree forest context means better habitat quality for roe deer.

(3) Shrub (Juniperus communis L., Genista florida L., Cytisus purgans (L.) Spach., Erica arborea L., Cytisus scoparius (L.) Link.) was also found to be dependent on tree density at Valsaín: Shrub cover (%) = 22,89063 – 0,01933•N – 0,033842•G – 0,00034•N_d<7,5 + 0,00035•N•G (with N = number of trees per hectare; N_d<7,5= number of trees with diameter<7.5 cm ; G= Basal area; R2 = 0,189; adjusted R2 = 0,130). Prediction power in this case was low although we found a significant relationship. Commonly, more shrub cover in a tree forest context means better habitat quality for roe deer. In addition, we measured browsing affection on shrubs and found that it was low.

(4) Our major conclusion at Valsaín is that although there is a relationship between pine stand forest and pasture (grass and shrubs), which could change game population's habitat condition; this is not the main limitation of game species populations. We did also not find a noticeable deer impact on plants.