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Concept and Evaluation

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Mit Unterstützung von Bund, Ländern und Europäischer Union

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Austrian Forest Biodiversity Index Concept and Evaluation

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Abstract | Forest biodiversity cannot be measured and monitored directly. Indicators are needed to tackle this task and must be based on scientifically valid relationships concerning different levels of biodiversity. In addition, indicators must aim at tangible goals for forest policy and other relevant stakeholders. In this BFW-Report we propose and thoroughly describe a single aggregated measure – the Austrian Forest Biodiversity Index (AFBI). This index is based on different indicators being weighted depending on their significance for the maintenance of forest species richness and genetic diversity. It consists of eight state, one pressure and four response indicators. Selection of state indicators is based on the general hypothesis that forests which mimic natural conditions or are characterized by structural elements of old-growth forests maintain a high number of forest dependent species and a high genetic richness therein. Impact by game and lifestock is taken as response indicator into account. Among the response indicators we consider the establishment of natural forest reserves, genetic reserve forests, seed stands and seed orchards as relevant. For each single indicator a reference value (not identical with target value) has been identified so that the actual indicator can be rescaled and be given a score that may theoretically vary between 0 (worst) and 100 (excellent). It is noteworthy that a single indicator can normally not amount to a score of 100 in managed forests. Single indicators have been weighted based on a web-based expert consultation. Proposed operational tools, especially for state indicators, are mainly based on available data provided by the Austrian forest inventory in order to keep costs low. The AFBI equals the weighted mean of all single indicators scores making this index simple to communicate and straightforward to apply. Although this index is mainly intended to be used for the whole federal territory, the AFBI was also calculated for different ecoregions indicating geographical differences. High values have been found in the Alps, slightly lower values characterize the north and north-eastern part of Austria. Overall, the AFBI amounts approximately to a score of 60 indicating high forest biodiversity.

Keywords | biodiversity indicators, conservation, monitoring, nature protection, sustainable forestry

1. Austrian Forest Biodiversity Index – Introduction

1.1. Biodiversity – International and national context

The protection and preservation of biodiversity has become an increasingly important topic in national and international environmental policy during the last two decades. The Convention on Biological Diversity (CBD), which resulted from the UN Earth Summit in Rio de Janeiro in 1992[1], defines biodiversity as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems"[2]. As a result of the Earth Summit and the Convention on Biological Diversity, biodiversity targets for the year 2010 were defined with the aim of significantly reducing the loss of biodiversity at international, national, and regional levels and thereby contributing to an improvement of the conditions for all species on the planet[3]. After the 2010 targets were unable to be reached, the CBD adopted the Strategic Plan for Biodiversity 2011 - 2020 at the Conference of Parties in Aichi-Nagoya. This plan formulated, amongst other things, five strategic goals which are subdivided into 20 biodiversity targets. It should serve as a framework for national and regional establishment of goals and biodiversity strategies and lead to an efficient and coherent implementation of the main objectives of the CBD[4]. In Austria the CBD was ratified in 1994. A national biodiversity strategy for Austria has existed since 1998 which is regularly reviewed, developed, and evaluated[5]. This national strategy is also highly relevant to the forest sector. The CBD defines forest biodiversity as "all the life forms found within forested areas and the ecological functions they perform. As such, forest biological diversity encompasses not just trees but the multitude of plants, animals and micro-organisms that inhabit forest areas and their associated genetic diversity." [6] Accordingly, conservation and protection of biological diversity are also entrenched within the Austrian Forest Act: "Sustainable forest management within the meaning of this Federal Act comprises the tending and use of forests in a way and at a rate, that maintains their biodiversity, productivity, regeneration capacity, their vitality and their potential to fulfil, now and in the future relevant ecological, economic, and social functions at local, national, and global levels, and that does not cause damage to other ecosystems. [7]"

Commitments to a monitoring of biodiversity in the forest sector arise in addition to the CBD and its resulting processes (particularly

1 http://www.un.org/geninfo/bp/enviro.html
2 http://www.cbd.int/convention/articles/default.shtml?a=cbd-02
3 https://www.cbd.int/doc/strategic-plan/2011-2020/Aichi-Targets-EN.pdf
4 http://www.naturschutz.at/konventionen/biodiversitaetskonvention/
5 Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2014): Biodiversitätsstrategie Österreich 2020+ - Vielfalt erhalten – Lebensqualität sichern und Wohlstand für uns und zukünftige Generationen sichern
6 http://www.cbd.int/forest/about.shtml
7 Anonymous (1975): Österreichisches Forstgesetz, Abschnitt 1 §3 [Austrian Forest Act, Section 1 §3] ; online at http://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bandesnormen&Gesetzesnummer=10010371

the *Pan-European Biological Landscape Diversity Strategy*[8], the EU Biodiversity Strategy[9], and the EU Biodiversity Action Plan) at international and EU level; and also due to the Alpine Convention[10], the Habitats Directive[11], and The Ministerial Conference on the Protection of Forests in Europe (*Forest Europe*[12]). However, not all of the above mentioned commitments are legally binding.

Consequently, legally binding and politically obligating norms exist in Austria to establish an effective monitoring system, which demonstrate the condition and trends of biodiversity and make an evaluation of forest biodiversity possible. According to the Austrian Biodiversity Strategy biodiversity shall be monitored by different methods including the Austrian Forest Biodiversity Index[13]. As a result, an important resource for policy consultation can be created. In various countries, different systems are already being implemented or are in the development phase[14] [15]. An effective and efficient monitoring system at national level should thereby be implemented if possible by a public institution, and already available data should be used or expanded upon with little effort, as otherwise the long-term success of the monitoring system is questionable[16].

1.2. Development of a monitoring system for forests in Austria

A project to develop suitable indicators to describe the condition and trends of biodiversity in Austria was initiated in 2004 by the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW). This initiative (MOBI-e – Monitoring, Biodiversity, and Development[17]) was expected to identify important indicators for all land, river and lake habitats, in order to make a long term contribution - after the establishment of a monitoring system - to reporting obligations amongst other things. For the forest sector, the Federal Research and Training Centre for Forests, Natural Hazards and Landscape (BFW) was mandated with the task of proposing biodiversity indicators for the forest while taking into account the results of international research and developments. As a consequence of these findings, a discussion paper for a comprehensive index for forest biodiversity in Austria was published[18], which is a basis for the following report.

[8] http://www.peblds.org/

[9] http://ec.europa.eu/environment/nature/biodiversity/comm2006/2020.htm

[10] http://www.alpconv.org/pages/default.aspx?AspxAutoDetectCookieSupport=1

[11] Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora

[12] http://www.foresteurope.org/

[13] Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2014): Biodiversitätsstrategie Österreich 2020+ - Vielfalt erhalten – Lebensqualität sichern und Wohlstand für uns und zukünftige Generationen sichern

[14] Lee, W., McGlone, M., Wright, E. (2005): Biodiversity inventory and monitoring: A review of national and international systems and a proposal for future biodiversity monitoring by the Department of Conservation. Landcare Research Contract Report: LC 0405/122.

[15] http://www.biodiversitymonitoring.ch/

[16] Moir, W.H., Block, W.M. (2001): Adaptive management on public land in the United States: Commitment or rhetoric. Environmental Management 28, 141-148.

[17] Bogner, D., Holzner, W. (Eds.)(2006): MOBI-e. Entwicklung eines Konzeptes für ein Biodiversitäts -Monitoring in Österreich. Report from the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management

[18] Geburek, T., Milasowszky, N., Frank, G., Konrad, H., Schadauer, K. (2010): The Austrian forest biodiversity index: all in one. Ecological Indicators 10: 753-761.

1.3. Austrian Forest Biodiversity Index (AFBI)

In order to make applicable observations about the condition and development of biodiversity, approaches for two considerable sets of problems must be available.

Measurement of forest biodiversity

Forest biodiversity cannot be determined or measured in its entirety. Even a comprehensive projection, which takes a multitude of scales and reference systems into account (genes, species, ecosystems), can only measure biodiversity to an approximate degree. Various approaches were previously developed in order to solve this problem and to describe the condition and/or development of biodiversity using individual or multiple indicators. In this paper the approach of using various indicators is adopted. It must be emphasised that this selection as well as the measurement and the recording criteria respectively, cannot occur in a fully objective manner.

Assessment of the indicators

Target values of individual indicators and their weighting play a central role in the compilation of the "Austrian Forest Biodiversity Index" – hereafter referred to as AFBI[19]. The definition of target values and also the weighting of indicators is an innovative element of this approach. It allows the direct evaluation of the degree of fulfilment and also of how closely the present situation relates to the ideal. Only in this way is it possible to evaluate the efficiency of biodiversity measures. Changes to the individual indicators as well as the AFBI have a very high, immediate value for policy consultation. Thereby the obtaining of the otherwise necessary technical expertise (*ex post*) to assess both indicator changes and weighting becomes superfluous, and the political decision makers are absolved from the assessment of indicator development.

The weighting of individual indicators is rejected by many scientists on the basis that a weighting is not fundamentally possible. However, this overlooks the fact that weighting always consciously or subconsciously takes place and frequently shifts to another, often political, level.

In the following case it was therefore explicitly attempted:

- To clearly separate measures and goals,
- to select biodiversity-relevant indicators from the nationwidely available basic data,
- to assess indicators on the basis of target values, and
- to weight indicators and subsequently to create an aggregated index.

The AFBI should enable the biodiversity of Austrian forests to be approximately described through suitable state indicators, pressure in-

[19] Failing, L., Gregory, R. (2003): Ten mistakes in designing biodiversity indicators for forest policy. Journal of Environmental Management 68: 121-132.

dicators and response indicators. The aim of the AFBI is to be principally applicable at **national level**, but may also deliver **valuable regional information** to policy makers. Suitable, already available data should be used where possible. A pragmatic approach is therefore used; not the desired, but the achievable is the maxim. The data for the AFBI, which is largely based upon measurements of the Austrian Forest Inventory (AFI)[20], should present **the current state** in an **extensive and representative** way. Past inventory periods can also be evaluated for some of the indicators, thereby demonstrating changes to individual indicators that have already occurred.

As previously stated, a target value shall be expertly determined for every individual indicator. For the state indicators these target values are orientated to **"close to nature"** forest conditions.

From a biodiversity point of view the optimum condition is approximately reached when the non-artificially fragmented forest contains species of trees which equate to the "potential natural vegetation"[21] and the anthropogenic influence on its genetic composition is negligible, when sufficient amounts of deadwood and veteran trees exist, when natural regeneration can occur without being negatively influenced by game and livestock and - where natural regeneration is not possible - a regeneration with regionally adapted reproductive material of high genetic diversity occurs. The diversity of forest communities is sufficiently secured in natural forest reserves and the gene pool of native tree species is additionally preserved through effective preservation measures (gene conservation reserves, conservation seed orchards).

Every individual indicator, as well as the AFBI itself, is valued on a scale from 0 (worst condition) to 100 (best condition). It must be explicitly stated here that a value of 100 biodiversity points in a managed forest is not always possible or is only possible in theory. It should also be emphasised that the AFBI exclusively describes forest biodiversity. It is not, therefore, an index that depicts forest sustainability, although individual indicators may be suitable for this.

The aggregation to the AFBI happens due to the weighting of individual indicators. This weighting resulted from an extensive online expert survey[22] . It was thereby also attempted to map the three main levels of biodiversity (genes, species, and ecosystems) through a relevant pool of experts. As comprehensive a group of experts as possible should be involved.

The strengths and weaknesses can be summarised as follows.

Strengths

- Forest biodiversity is factored in at all levels (genes, species, and ecosystems[23]).
- The AFBI is principally based upon previously acquired data and is therefore cost effective.
- Conclusions about forest biodiversity are representative for the whole national territory.

[20] More information about the applicability of AFI data can be found in Annex II, p. 64

[21] It should be noted that the "potential natural vegetation" is not an unchanging permanent state, but can change over time, especially in regard to climate change.

[22] More information about the expert survey can be found in Annex II, p. 63

[23] Ecosystems (*sensu lato*) here also includes habitat types and forest types.

- Retrospective evaluations are possible to some extent.
- The AFBI is "adaptable", which means that target values and/or the weighting of individual indicators can be adapted to new scientific evidence and the previous index-values can be retrospectively redetermined.
- The ability to communicate the AFBI is very high.

Weaknesses
- The target values are based upon only few scientific sources.
- Species biodiversity is only recorded for tree species as host organisms, other organisms are only indirectly considered.
- Genetic diversity, with the exception of one tree species, is only indirectly assessed.
- Data for which no target value can be derived or which is not available for the complete national territory cannot be taken into account.

1.4. Basic data

The following data sources are available for the determination of indicators:
- Austrian Forest Inventory
  Indicators 1- 7 are based upon the data of the Austrian Forest Inventory. The entire commercial forest is used for basic data. This encompasses the high production forest, high protective forest with yield, coppice production forest, and riparian coppice production forest management types.[24]
- Natural Forest Reserves Programme.
- BFW Genetic Inventory (supplementary survey AFI 2000/2002 and 2007/2010)
- *European Information System on Forest Genetic Resources* (EU-FGIS)[25]
- Federal Forest Office; National Register (Natreg-database)
- Seed Plantation Programme of the Federal Ministry of Agriculture, Forestry, Environment and Water Management

1.5. Further approaches for indicator systems and indices for the recording of forest biodiversity

Aside from - or building on - the European indicator systems of SEBI (2010) and FOREST EUROPE (1993 and 2003), there are various approaches towards the measurement and observation of the condition

[24] Further details about the recording of the AFI can be found at: http://bfw.ac.at/700/pdf/DA_2009_Endfassung_klein.pdf
[25] http://www.eufgis.org/

of and change to (forest) biodiversity. A good overview of the European criteria and indicator systems is made by Lier et al. (2013)[26].

Some approaches, which also accumulate indicators, should be briefly mentioned at this point. For British forests, potential biodiversity indicators were suggested in a paper by Ferris and Humphrey (1999)[27]. In Belgium, the "*authenticity index*"- an index for the measurement of forest biodiversity aspects at stand level - was designed by van Loy et al. (2003)[28] and is based upon data of the national forest inventory. Petriccone et al. (2007)[29] designed the Forest Status Indicator (FSI) – a concept for a compiled index at European level – which consists of various methods (EU Forest Focus and UN/ECE CLRTAP ICPs, national forest inventories, Natura 2000, LTER-Europe) which describe the condition of European forest biodiversity.

Outside Europe the Canadian Biodiversity Index (CBI)[30] is noteworthy, however it is not focused solely on forest ecosystems. In South Africa a biodiversity intactness index was suggested by Scholes and Biggs (2005)[31]. This index is designed to show differences in different plants, mammals, birds, reptiles and amphibians, ecosystems, and land use forms at population level in a determined geographical zone. Such an approach is currently not feasible for the forest sector in Austria due to a lack of data and resources.

2. Austrian Forest Biodiversity Index - Indicators

The indicators used in this concept serve as tools to quantify forest biodiversity. The index consists of eight status indicators, one pressure indicator, and four response indicators.

Reliability, validity and objectivity were decisive criteria in the selection of these indicators. The measurement findings should be trustworthy (reliable), reproducible regardless of the person recording (objective), and the measurement design must be suitable for its objective (valid) [32].

The approach above bases itself upon the concept that forest biodiversity in Austria can be best described using valuable, already available data – which can largely be sourced from the Austrian Forest Inventory. Therefore, only such indicators were chosen for which the target values could be defined, and for which basic data were available or were presently being compiled. For this reason, certain units relevant to forest biodiversity, e.g. the vertical and horizontal forest structure, or the presence of special indicator species (lichens, birds, etc.), have not been considered to date.

26 Lier, M., Parviainen, J., Nivet, C., Gosselin, M.,Gosselin, F., Paillet, Y. (2013): The use of European criteria and indicator systems for measuring changes in forest biodiversity. In: Kraus D., Krumm F. (eds). Integrative approaches as an opportunity for the conservation of forest biodiversity. European Forest Institute. 284 pp.

27 Ferris, R., Humphrey, J.W. (1999): A review of potential biodiversity indicators for application in British forests. Forestry 72: 313–328.

28 Van Loy, K., Vandekerkhove, K., Van Den Meersschaut, D. (2003): Assessing and monitoring the status of biodiversity-related aspects in Flemish forests by use of the Flemish forest inventory data. In: Corona, P., Kohl M., Marchetti, M. (Eds.), Advances in forest inventory for sustainable forest management and biodiversity monitoring. Forestry Sciences Series 76. Kluwer Academic Publishers, Dordrecht, The Netherlands: 405–430.

29 Petriccione, B., Cindolo, C., Cocciufa, C. , Ferlazzo, S., Parisi, G. (2007): Development and harmonization of a Forest Status Indicator (FSI). European Enviroment Agency and Italian Forest Service, CONECOFOR Board.

30 Grosshans, R., Murray, C., Pinter, L., Smith, R., Venema, H. (2006): Field testing the Draft Canadian Biodiversity Index: a report on applying real ecosystem data to the CBI. In: Prepared for the Federal/Provincial/Territorial Biodiversity Working Group. Monitoring and Reporting Sub-Group, Environment Canada 5 July 2006, 74 pp. online: https://www.iisd.org/pdf/2006/measure_cbi.pdf

31 Scholes, R.J., Biggs, R. (2005): A biodiversity intactness index. Nature 434: 45–49.

32 Himme, A.(2009): Gütekriterien der Messung: Reliabilität, Validität and Generalisierbarkeit. Albers, S., Klapper, D., Konradt, U., Walter, A. and J. Wolf (Hrsg.), Methodik der empirischen Forschung, 3. Auflage, Gabler, Wiesbaden: 485-500

Qualitätskriterien für Indikatoren

In the following sections the individual indicators will be described. For every indicator there will be:

- A brief summary of why this indicator is significant to forest biodiversity
- The name of the basic data and determined target value
- A description of the survey and the evaluation
- An indication of the measurement period.

2.1. Status indicators

2.1.1. Status indicators – Natural tree species composition

The potential natural forest community (PNFC) is derived from the concept of the potential natural vegetation (PNV) of a forest site[33]. The PNFC is defined as the forest community that would occur at a site under the site-specific environmental conditions if direct human influence could be excluded. The PNFC is considered to be an important reference unit of characteristic biodiversity under site-specific environmental conditions.

I1 Tree species of potential natural forest communities (PNFC)

Basic data: Austrian Forest Inventory. The PNFC is expertly determined for all sampling areas within the AFI using an identification key.

Measurement: The indicator is determined for each sampling plot and then aggregated. Next, the occurrence and species-richness of the community defining tree species are determined separately for the upper stand layers above 1.3 m and the lowest layers below 1.3m (Annex I Table 1)[34]. The cover-abundance is determined with a technique modified for the AFI, which is based upon the Braun-Blanquet method.[35]

Target value: The community defining tree species of the potential natural forest communities are present at the AFI sampling area.

Evaluation:

- **For forest communities with only one community defining tree species, and tree species joined with the word "or"**For the tree species joined with "or", the occurrence of at least one of the named species is required.

Criterion	Biodiversity points
The forest community characterising tree species is/are present: **both** at a height ≥1.3 m with altogether more than 50% ground cover **and** at a height < 1.3m.	100
The forest community characterising tree species is/are present: **both** at a height ≥1.3 m **and** at a height < 1.3m.	75
The forest community characterising tree species is/are present: **either** at a height ≥1.3 m **or** at a height < 1.3m.	50
The forest community characterising tree species is/are present: **neither at a height** ≥1.3 m **nor** at a height < 1.3m.	0

- **For forest communities with various forest community characterising tree species joined with the word "and"**
  For the forest community characterising tree species joined with "and", biodiversity points are first calculated followed by the average for the particular forest community.

Criterion	Biodiversity points
The forest community characterising tree species is/are present: **both** at a height ≥1.3 m with altogether more than 25% ground cover **and** at a height < 1.3m.	100
The forest community characterising tree species is/are present: **both** at a heigth ≥1.3 m **and** at a heigth < 1.3m.	75
The forest community characterising tree species is/are present: **either** at a heigth ≥1.3 m **or** at a heigth < 1.3m.	50
The forest community characterising tree species is/are present: **neither at a height** ≥1.3 m **nor** at a heigth < 1.3m.	0

Monitoring interval: Every measurement period of the Austrian Forest Inventory.

33 Tüxen, R. (1956): Die heutige potentielle natürliche Vegetation als Gegenstand der Vegetationskartierung. Angewandte Pflanzensoziologie 13: 5-42.

34 http://bfw.ac.at/700/pdf/DA_2009_Endfassung_klein.pdf Page 178 ff.

35 Where no stand layer below 1.3m is present, this layer will not be considered.

Neophytes are tree species that were only introduced to Austria in modern times (since 1492). The occurrence of neophytes can have negative effects on the biological diversity of the forest.

I2 Neophytic tree species

Basic data: AFI

Measurement: Presence of neophytes on the AFI sampling areas. The tree species concerned are listed in the Annex 1 (Table 2).

Target value: AFI sample plots contain no neophytic tree species.

Evaluation:

Criterion	Biodiversity points
No neophytic tree species on the AFI sample plots	100
Neophytic tree species on the AFI sample plots	0

Monitoring interval: Every measurement period of the Austrian Forest Inventory.

2.1.2. Status indicators – Elements of natural forest structure

Deadwood is a key indicator for biodiversity in forests. It serves as a habitat for many species, is an important part of the food chain and nutrient cycle, and is important for humus formation as well as soil development.

I3 Deadwood

Basic data: AFI

Measurement: Standing deadwood volume (DBH ≥ 10 cm) and volume of lying deadwood with ≥ 10 cm top end diameter shall be measured on every AFI sample plot. Deadwood percentages shall be calculated in relation to the existing total growing stock[36].

Target value: Deadwood volume (standing and lying) constitutes 10% of existing total growing stock.

Evaluation: A dead wood percentage of 10% or over of the total growing stock corresponds to 100 biodiversity points, a lower percentage receives proportionally fewer points.

Monitoring interval: Every measurement period of the Austrian Forest Inventory.

Note: No scientifically based data exists which can give a concrete figure for the necessary deadwood amount in different forest types and at different forest ages from a biodiversity point of view. Inevitably, therefore, the previously stated target value of 10% can only be expertly ascertained. It should be noted that at a small scale non-managed forests can also contain considerably higher deadwood percentages[37] .

[36] Due to the inventory method for sample tree recording (angle count sampling, division of the sampling area), a sample area-wise evaluation is not possible for this indicator.

[37] Stokland, J.M., Tomter, S.M., Söderberg, U. (2004): Development of deadwood indicators for biodiversity monitoring: Experiences from Scandinavia. European Forest Institute, No. 51: 207-229.
Humphrey, J.W., Sippolar, A.-L., Lempérière, G., Dodelin, B., Alexander, K.N.A., Butler, J.E. (2004): Deadwood as an indicator of biodiversity in European forests: from theory to operational guidance. European Forest Institute, No. 51: 194-206.

I4 Veteran Trees

Basic data: AFI

Measurement: Minimum DBH values for the classification of veteran trees are specified in Annex I (Table 3) according to forest communities for tree species and tree species groups respectively.

Target value: The minimum percentage of veteran trees in every forest community is 5% of the stand basal area.

Evaluation:
A veteran tree percentage of 5% or more of the stand basal area corresponds to 100 biodiversity points, a smaller percentage receives proportionally fewer points.

Monitoring interval: Every measurement period of the Austrian Forest Inventory.

Note: No scientifically based data exists which can give a concrete figure for the necessary amount of veteran trees in different forest types from a biodiversity point of view. Inevitably therefore the previously stated target value of 5% can only be expertly ascertained. It should be noted that at a small scale non-managed forests can also contain considerably higher percentages of veteran trees.

Veteran trees have a special significance for forest biodiversity. They offer habitats for many species through their individual tree structures, as well as deadwood proportions in various stages of decomposition.

2.1.3. Status indicators – securing genetically diverse future tree generations

I5 Presence of forest regeneration

Basic data: AFI. This indicator is only measured on areas where “regeneration is necessary“, (unstocked forest land, young growth, stands in the last one-fifth of rotation time). This allows the exclusion of stands that have no regeneration layer because of natural reasons.

Measurement: Determination of the presence of regeneration. If no regeneration as per the minimum criteria is present, the underlying cause will be noted (Annex I, Table 4).

Target value: Regeneration is present on all AFI sample plots where it is necessary.

From an evolutionary perspective, the sustainable existence of tree species is not threatened as long as they are able to independently reproduce from generation to generation. As a general rule, forest stands which are able to regenerate naturally over many mast years are more genetically diverse than planted stands. Naturally regenerated stands are, as a rule, better adapted to local site conditions and furthermore display a greater structural diversity.

Evaluation:

Regeneration	Cause	Biodiversity points
Present and neccesary	-	100
Not present, but neccesary	uantity of plants does not reach minimum quantity	25
Not present, but neccesary	Only regeneration ≤ 10 cm	10
Not present, but neccesary	No regeneration	0

Monitoring interval: Every measurement period of the Austrian Forest Inventory.

I6 Regeneration type

Basic data: AFI. Sample plots with trees ≤ 1.30 m height (Juvenile I)

Measurement: Determination of the regeneration type according to AFI on free standing regeneration areas (Juvenile I on at least 500 m^2)

Target value: All trees up to and including 1.30 m height (Juvenile I) occur due to natural regeneration

Evaluation:

Type of regeneration	Biodiversity points
Only natural regeneration	100
Natural regeneration supplemented with artificial regeneration	75
Artificial regeneration supplemented with natural regeneration	25
Only artificial regeneration	0

Monitoring interval: Every measurement period of the Austrian Forest Inventory.

Note: For this indicator only very few AFI sample plots are taken into account. Here only the free standing juvenile trees will be evaluated, as only these are a distinct point of origin for the next stand.

[38] To date, only genetic data for Norway spruce has been recorded and assessed, as a first step towards the recording of the influence on the gene pool of Austrian forest trees.

[39] Gregorius, H.R. (1984): A unique genetic distance. Biometrical Journal 26: 13-18.

[40] Sperisen, C., Büchler, U., Gugerli, F., Mátyás, G., Geburek, Th., Vendramin, G.G. (2001): Tandem repeats in plant mitochondrial genomes: application to the analysis of population differentiation in the conifer Norway spruce. Molecular Ecology 10: 257-263.

[41] Tollefsrud, M.M., Kisling, R., Gugerli, F., Johnsen, Ø., Skrøppa, T., Cheddadi, R., van der Knap, W.O., Latalowa, M., Terhürne-Berson, R., Litt, Th., Geburek, Th., Brochmann, C., Sperisen, C. (2008): Genetic consequences of glacial survival and postglacial colonization in Norway spruce: combined analysis of mitochondrial DNA and fossil pollen. Molecular Ecology 17: 4134-4150.

[42] Zulka, P., Lexer, W. (2004): Auswirkungen der Lebensraumzerschneidung auf die biologische Vielfalt. Natur Land Salzburg, Heft 1: 30–34.

I7 Naturalness of the gene pool[38]

Forest stands, whose gene pools are not affected by humans, have as a rule a high genetic adaptability and diversity.

Basic data: In the course of the Austrian Forest Inventory, needle samples were taken in the measurement periods 2000/2002 and 2007/2009 from spruce trees on all sample plots and were analysed at a molecular level.

Measurement: Comparison of Norway spruce DNA-data from the AFI sample plots to that which would be expected on these sites in the absence of human influence. The genetic distance[39] between the observed and expected genetic type is calculated. As genetic tool molecular mitochondrial markers[40] are used, which are maternally inherited in Norway spruce and are selectively neutral.[41] These characteristics make it possible that for each AFI plot the expected genetic type can be identified taking the postglacial immigration history into account. For all AFI plots in which Norway spruce is found the genetic distance is averaged. It is stressed that this indicator is limited to the natural range of the spruce, as the influencing of the gene pool for spruce outside this area is already assessed through indicator 1.

Target values: The gene pools on all stands of tree species inside their natural range are not affected by humans.

Evaluation: Calculation of the probability of naturalness of the gene pool. This value multiplied by 100 is on a scale of 0 to 100 and equates to the biodiversity points.

Monitoring interval: Currently undetermined

Note: It would be preferable to make this indicator usable and/or to use this indicator for other tree species (with the relevant experimental basis).

2.1.4. Forest – Landscape-Mosaic

The fragmentation of forest habitats (both within the forest and also to other landscape elements) impacts upon forest biodiversity. Traffic infrastructure especially, but also industrial and settlement measures, lead to the isolation of populations. Consequences include changes in species composition, genetic depletion, interruption of gene flow and many others; it can also lead to an increase in habitat diversity. Specialised species are, as a rule, more strongly influenced by these effects[42].

I8 Forest fragmentation

Basic data: Currently a forest map of Austria with a resolution of one meter is under construction. This will be initially composed from laser scanning data, later from aerial images. The Austria-wide map is expected to be finished in a few years' time.

Measurement: In preparation, values will be placed upon the different importance of inner and outer fragmentation.

Target values: Forest are not anthropogenicaly fragmented.

Evaluation: Not determined.

Monitoring interval: Currently undetermined.

2.2. Pressure Indicator

Game population and forest pasture have a strong impact on forest vegetation, especially on regeneration. The impact due to pasture currently only affects around 8% of forest areas, while game occurs almost everywhere. Browsing by game hinders regeneration and leads to selective loss of tree species.

I9 Browsing by game and livestock

Basic data: AFI. This indicator only takes areas where regeneration occurs into account. Furthermore, areas are taken into account upon which regeneration does not occur, and game or pasture livestock are listed as the inhibiting factor.

Measurement: Browsing damage is measured at AFI sample plots with existing regeneration. For this, the current plant leader is assessed. When more than one tree species characteristic for a certain forest community (Annex I, Table 1) is present, the most damaged tree species is considered of all obligatory species (tree species joined by "and"). In forest community with facultative forest tree species (tree species joined by "or") the less damaged forest tree species is considered independent of its actual abundance.

Target value: No AFI sample plots where regeneration is present show a significant impact on the forest community defining tree species.

Evaluation:

Browsing intensity	Biodiversity points
No browsing on the forest community defining tree species	100
Less than 50% of individuals of the key tree species defining the forest type destroyed by browsing.	60
Between 50% and 90% of individuals of the key tree species defining the forest type destroyed by browsing.	25
Over 90% of individuals of the key tree species defining the forest type destroyed by browsing.	0
Regeneration absent, impeding factor browsing or forest pasture[43].	0

Repetition interval: Every measurement period of the Austrian Forest Inventory.

43 http://bfw.ac.at/700/pdf/DA_2009_End-fassung_klein.pdf

2.3. Response indicators

Indicators were chosen which proved themselves effective in protecting and renewing forest biodiversity in the past. It was aimed to take the three levels of biodiversity (genes, species, and ecosystems) into account. These indicators were only recorded across a regional or supraregional area.

I10 Natural forest reserves

The establishment of a natural forest reserve network in Austria has the aim of preserving, at least as exemplarily, the natural dynamic and species composition of all forest types that occur in Austria[44]. Moreover, natural forest reserves will be used as reference areas for natural forest development and used for educational purposes. Natural forest reserves are completely protected from direct forest management interventions. Hunting is necessary in order not to endanger forest regeneration.

Basic data: Natural Forest Reserves Programme[45]

Target value: Every forest community (level of association) should be represented in at least one natural forest reserve in all of the 22 ecoregions in which they occur (see Austrian Natural Forest Reserves Programme).

Measurement: Comparison between already existing natural forest reserves[46] and the relevant target value (Annex I, Table 5).

The aim of the Austrian Natural Forest Reserves Programme is that every forest community in every forest growth area should be represented at least once. This approach was chosen in order to avoid a relative minimum proportion of the forest area without scientific justification. The acquisition of areas took place within the framework of contractual nature conservation after the registration of suitable areas by forest owners. The comparison with the target values in Table 5 (Annex I) is based upon the occurrence of the forest community at association level in the forest growth areas. Forest communities which are rare or which occur on small areas are thereby taken into account at an equal rate to those which span large areas or those on a zonal scale. The degree of fulfilment is calculated without reference to area, i.e. the rare and small-scale forest communities are more strongly weighted.

Evaluation: A complete degree of fulfilment is not plausible, due to the fact that stands for some of the forest communities at association level either do not exist with the required criteria, or are not made available as natural forest reserves by their owners. This difference between the theoretical reference value and the maximum value attained under real conditions can be estimated at around one third. The relevant degree of fulfilment as a percentage is multiplied by a factor of 1.5 and then corresponds to the biodiversity points.

Monitoring interval: Synchronised with AFI periods.

[44] Frank, G. (1998): Überlegungen zur Mindestgröße der Naturwaldreservate und deren Abgrenzung zu Generhaltungswäldern. In: Geburek, Th., Heinze, B. (eds.). Erhaltung genetischer Ressourcen im Wald. Ecomed-Verlag, Landsberg: 205-238.

[45] Forstliche Grundsätze des Bundes für die Einrichtung eines österreichischen Netzes von Naturwaldreservaten, BMLFUW Zl. 55.700/20-VB4/95
Franz, G., Müller, F., (2003): Voluntary approaches in protection of forests in Austria. Environmental Science & Policy: 261-269

[46] http://www.naturwaldreservate.at

In genetic reserve forests, the preservation of the evolutionary adaptability of certain tree species is especially encouraged. To this end a sufficient amount of adaptable populations were identified, where genetic diversity was to be preserved. This can be strengthened by target-oriented forest management, e.g. by encouraging natural regeneration and/or the preservation of rarer tree species and shrubs, amongst other things[47]. The selection of the gene conservation reserves is determined by the criteria of a harmonised European programme[48].

In production forestry, artificial regeneration cannot be completely forgone. Using suitable indigenous propagation material with high genetic diversity has a potentially positive influence on biodiversity. Therefore propagation material should be sourced from as many suitable stands as possible and should be as evenly used as possible. On the other hand, reforestation with unsuitable propagation material can change the gene pool of the local population and in extreme situations have serious consequences.

I11 Genetic reserve forests

Basic data: EUFGIS (*European Information System on Forest Genetic Resources*) and national database.

Target value: For every tree species at least one gene conservation reserve should be available (Annex I, Table 6).[49]

Measurement: Comparison between already existing gene conservation reserves and the relevant target value.

Evaluation: The percentaged proportion of existing genetic reserve forests compared to the target value equals the biodiversity points.

Measurement time-frame: Synchronised with AFI periods.

I12 Seed stands – optimising the use of available genetic resources

Basic data: Records of the Federal Forest Office and National Register

Target value: Even utilization of the available seed stands

Measurement: This indicator takes both the number of actually harvested seed stands and their even representation in the past monitoring period in dependence of the tree species specific need for seeds into account. For each forest tree species an evenness measure of the usage of seed stands is calculated. The calculations take also seed imports and translocated forest reproductive material from EU Member States into account. The significance of the forest tree species is expertly considered for this indicator. The indicator ascertainment is complex and is further explained in Annex II.

Evaluation: The even distribution value calculated across all tree species is multiplied by 100 and constitutes the biodiversity points.

Monitoring period: Every 10 years.

Remark: This indicator considers for the first time a management of genetic resources tailored to suit market needs. Moreover tree species specific peculiarities and also the transfer across borders are considered. Within the framework of *Forest Europe* as one of the biodiversity indicators the area of seed stands is considered in the *State of Europe's Forest Report*[50] for each country (Indicator 4.6: Genetic Resources, Criterion 4: Maintenance, Conservation and Appropriate Enhancement of Biological Diversity). Neither tree species specific peculiarities nor the actual use of the genetic resources are accounted for.

[47] Geburek, T., Müller, F., (2006): Nachhaltige Nutzung von genetischen Waldressourcen in Österreich – Evaluierung bisheriger Maßnahmen und Perspektiven für zukünftiges Handeln. BFW-Berichte Nr. 134, 36 p.

I13 Conservation seed orchards[51]

Basic data: BFW

Target value: Seed producing orchards[53] should be present, based upon an expert assessment, taking into account the conservation status, the difficulty of harvesting, as well as the seed demand of the tree species (Annex I, Table 7). Only orchards which are admitted to the BMLFUW (Federal Ministry of Agriculture, Forestry, Environment and Water Management) Plantation Programme or match the programme's quality requirements are valid as seed orchards. For the categorisation as a seed producing plantation, at least one seed harvest must take place within an inclusion period of 10 years.

Measurement: Comparison of the actual number of seed orchards with the targeted number.

Evaluation: Achieved percentage corresponds to the biodiversity points

Monitoring period: Every 10 years

Conservation seed orchard for wild pear managed by BFW

Seeds from rare and/or endangered tree species either cannot be harvested in forests, or can only be harvested with great expenditure of resources, due to high costs and/or the small, often reproductively isolated population sizes. Thus the domestic seed demand for certain species is largely covered by imports from Eastern Europe[52]. Certain tree species (e.g. *Sorbus* spec., *Malus sylvestris*, *Pyrus pyraster*, in local cases also *Abies alba*) already fall below critical population sizes. A self-reproducing population can be restored through a seed conservation orchard, and the gene pool can be secured. Seed conservation orchards enable a production of seeds with a high genetic diversity for these species, which is largely not feasible when they occur naturally.

48 EUFGIS (*European Information System on Forest Genetic Resources*) avaialbkle online www.eufgis.org, Minimum requirements for genetic forest reserves online at http://portal.eufgis.org/data-standards/

49 The target values were expertly determined with consideration of the project "Mapping of flora in central Europe". See also Niklfeld, H. (1971): Bericht über die Kartierung der Flora Mitteleuropas. Taxon 20: 545–574.

50 http://www.foresteurope.org/full_SoEF

51 It should be noted that seed orchards aiming at increasing productivity (high performance orchards) are not meant here.

52 The importation of these rare and/or endangered tree species (with the exception of (*Abies alba)* will not be used for the ascertainment of the indicator I12.

53 Whether a seed orchard can be characterised as seed bearing is based upon harvesting criteria of the BFW.

3. Weighting of Indicators

3.1. Online survey

The aggregation of the indicators into a unified value is a speciality of the AFBI. Various methods exist in principle for the weighting of indicators. The choice of method heavily depends upon the number of indicators. Different methods were examined in the preliminary stages by the AFBI for their suitability to be weighted. Due to the high number of indicators, methods such as the *Analytical Hierarchy Process*[54], which makes pairwise comparisons of indicators are not suitable for the AFBI.

The indicators were already allocated weights in the Mob-e process[55]. In the course of this project, methods for the weighting of indicators were examined and a suitable approach was selected for the existing concept, in order to provide as broad a scientific basis as possible for the weighting. The weighting of the indicators results from an online survey with the software package SoSciSurvey[56] (see Annex II).

[54] Saaty, T. (1990): Multicriteria decision making - the analytic hierarchy process. Planning, priority setting, resource allocation. 2nd edition. RWS Publishing, Pittsburgh

[55] Geburek, T., Milasowszky, N., Frank, G., Konrad, H., Schadauer, K. (2010): The Austrian forest biodiversity index: all in one. Ecological Indicators 10: 753-761.

[56] https://www.soscisurvey.de/

3.2. Selection of experts and participation

For the selection of experts to participate in the survey it was ensured that these experts were active in various biodiversity disciplines (genes, species, and ecosystems). In total 150 scientists from the German-speaking region (Austria, Germany, Switzerland) were contacted.

3.3. Results of the survey and weighting

In total 150 experts were contacted and 63 replies were eventually analyzed.

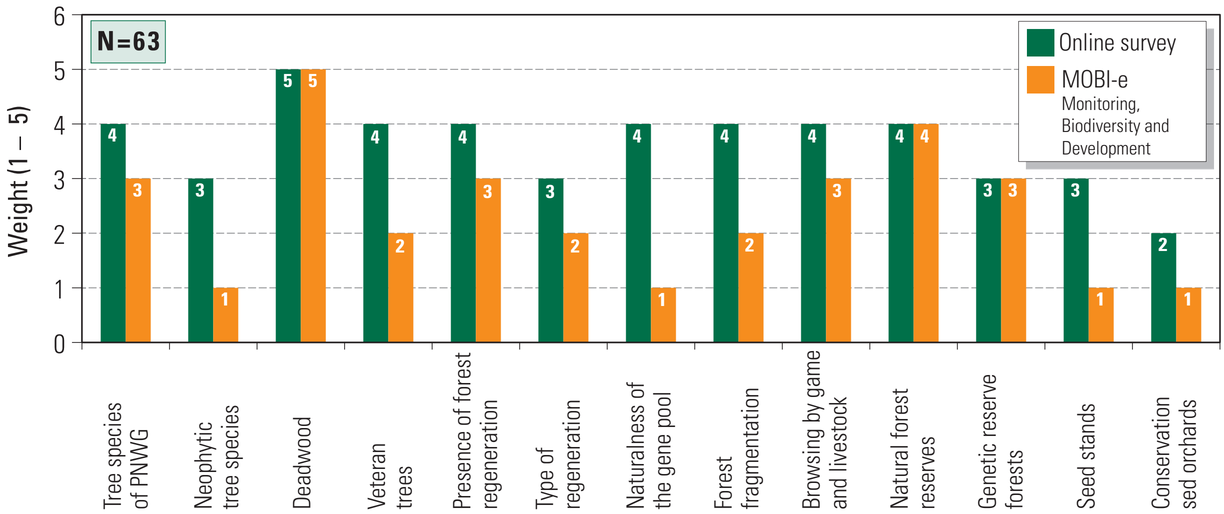
As some indicators are based upon information from the AFI, experts were also asked about their knowledge of this inventory. Around half of the respondents knew the inventory and its recording process.

The weighting resulting from the online survey deviated only insignificantly from that of MOBI-e. The indicator "deadwood" was seen as especially important by the experts (weight 5 on a scale of 1-5). Weight 4 was given to the presence of the tree species of the

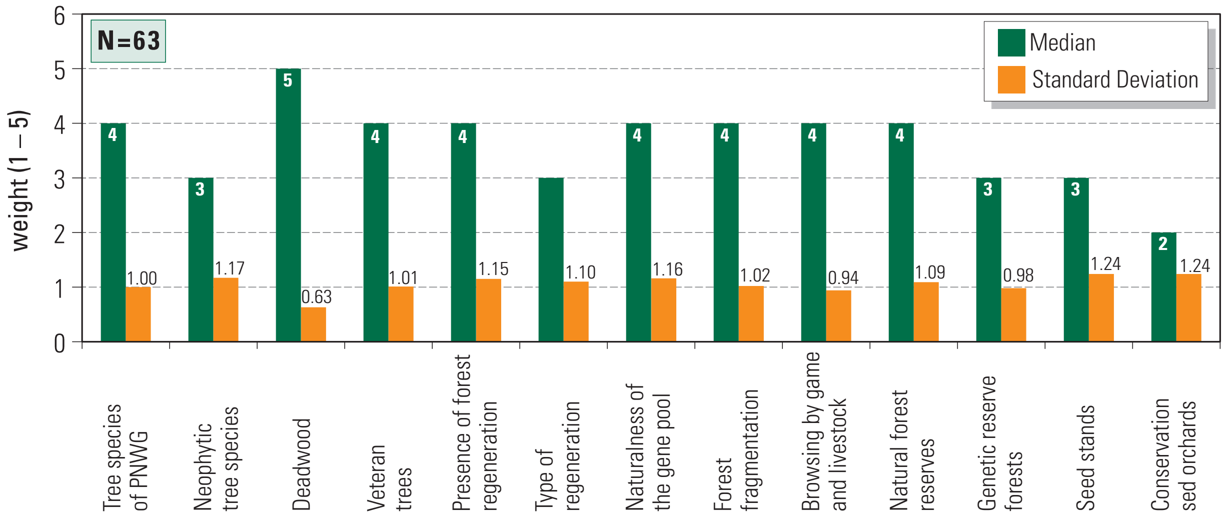
Expertise (self-evaluation on individual knowledge of the Austrian Forestry Inventory)		
	Number	**%**
very good	10	15.9
good	34	54.0
sufficient	17	27.0
incomplete	2	3.2
insufficient	0	0.0

PNFC, veteran trees, the presence of regeneration, the naturalness of the gene pool, the influence of forest fragmentation, browsing and pasture impact, and a sufficient number of natural forest reserves respectively. The impact of neophytes and of the regeneration type on forest biodiversity as well as a sufficient number of gene reserves, the optimised use of available seed stands and a minimal import of seed and plant goods was seen as moderately important (weight 3), while a sufficient number of reproducing seed orchards was given the lowest weight. From the extent of the standard deviation it can be seen that especially the use of available genetic resources (seed stands) and seed orchards were evaluated quite differently by the experts.

Participants		
Country	Contacted experts	Replies
Austria	64	26
Switzerland	20	9
Germany	66	28
Total	150	63
Reply rate (%)		42



Weighting of indicators based on the exert online survey and results of the MOBI-e project.



Weighting of indicators (median) and standard deviation based on the expert online survey.

4. Results

Indicators 1-6 and 9 are based upon data from the Austrian National Forest Inventory. The entire harvested forest is utilised as basic data. This includes the forestry systems high forest – production forest, high forest – protection forest with commercial yield, terrestrial coppice production forest, and riparian coppice production forest.

The indicators 1-6 and 9 were determined until now for potential natural forest community, natural region (Innen-und Zentralalpen, Randalpen, Nördliches Alpenvorland, Mühl- und Waldviertel, Sommerwarmer Osten) and refer in this document to the inventory of 2007/2009.

In the calculation of the total biodiversity points of an indicator, the values of the natural forest community (and natural region) were weighted for proportion of the area and their occurrence on AFI sample plots respectively.

The natural regions are composed of the following eco regions: Regions of provenance

Innen- und Zwischenalpen
[Central and Intermediate Alps]

- 1.1 Central Alps – continental central zone
- 1.2 Subcontinental Central Alps – west part
- 1.3 Subcontinental Central Alps – east part

- 2.1 North intermediate Alps – west part
- 2.2 North intermediate Alps – eastpart

- 3.1 East intermediate Alps – north part
- 3.2 East intermediate Alps – south part
- 3.3 South intermediate Alps

Randalpen
[Alpine Fringe]

- 4.1 North border of the Alps – west part
- 4.2 North border of the Alps – east part

- 5.1 Lower Austria east border of the Alps
- 5.2 Bucklige Welt
- 5.3 East and middle Styrian mountain area
- 5.4 West Styrian mountain area

- 6.1 South border range of mountains
- 6.2 Basin of Klagenfurt (Carinthia)

Nördliches Alpenvorland
[Northern Alpine Foreland]

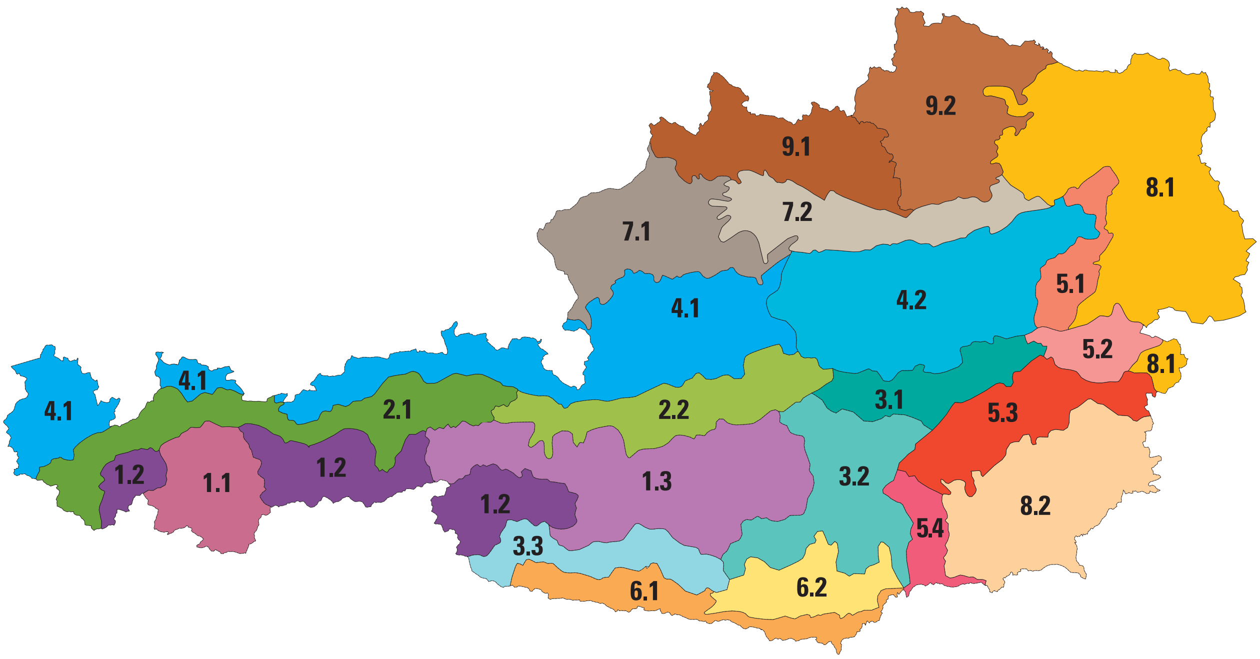
- 7.1 Northern foothills – west part
- 7.2 Northern foothills – east part

Sommerwarmer Osten
[Pannonian and Subillyrian Country]

- 8.1 Pannonian lowland and hilly country
- 8.2 Subillyrian hilly and terrace country

Mühl- Waldviertel

- 9.1 Mühlviertel
- 9.2 Waldviertel



4.1. Indicators

I1 Tree species of the potential natural forest community (PNFC)

Natural Forest Community	Number of AFI plots	Biodiversity points
Larch – stone pine forest	135	74
Larch forest	31	59
Subalpine spruce forest	1,195	76
Montane spruce forest	532	78
Spruce – fir forest	1,638	49
Spruce – fir – beech forest	3,808	50
Beech forest	1,641	58
Oak – hornbeam forest	973	44
Acidophilous oak forest	125	50
Thermophilous oak forest	60	22
Scots pine – oak forest	148	53
Mixed lime forest	16	72
Sycamore forest	63	57
Sycamore – ash forest	286	71
Black alder – ash forest	199	62
Black alder forest marsh	54	33
Grey alder forest	107	59
Pine – birch – bogland forest	8	63
Calcareous Scots pine forest	83	47
Acidophilous Scots pine forest	44	56
Austrian black pine forest	10	75
Riparian poplar-willow forest	78	43
Riparian hardwood forest	81	61
Ash swamp forest	30	63
Natural region	**Number of AFI points**	**Biodiversity points**
Innen- und Zwischenalpen	3,785	59
Randalpen	4,759	58
Nördliches Alpenvorland	474	48
Sommerwarmer Osten	1,103	50
Mühl- und Waldviertel	1,225	46
Total	**11,346**	**56**

It is apparent from these indicators that relatively small values occur for such natural forest communities, where fir is present as a natural tree species and where it is encountered at lower altitudes respectively. As the forest communities “spruce – fir forest” and “spruce – fir – beech forest” cover relatively large areas, a stronger occurrence of fir in these forest communities would strongly influence the biodiversity points of these indicators.

I2 Neophytic tree species

High biodiversity points were scored across all natural regions Austria-wide. There is a small potential for improvement in the "Sommerwarmen Osten" region.

Natural Forest Community	Number of AFI plots	Biodiversity points
Larch – stone pine forest	136	100
Larch forest	31	100
Subalpine spruce forest	1,195	100
Montane spruce forest	532	99
Spruce – fir forest	1,638	100
Spruce – fir – beech forest	3,807	99
Beech forest	1,641	96
Oak – hornbeam forest	973	83
Acidophilous oak forest	125	89
Thermophilous oak forest	60	47
Scots pine – oak forest	148	93
Mixed lime forest	16	100
Sycamore forest	63	100
Sycamore – ash forest	286	97
Black alder – ash forest	199	90
Black alder forest marsh	54	98
Grey alder forest	107	99
Pine – birch – bogland forest	8	100
Calcareous Scots pine forest	83	95
Acidophilous Scots pine forest	44	100
Austrian black pine forest	10	90
Riparian poplar-willow forest	78	73
Riparian hardwood forest	81	64
Ash swamp forest	30	100
Natural region	**Number of AFI plots**	**Biodiversity points**
Innen- und Zwischenalpen	3,785	99
Randalpen	4,758	98
Nördliches Alpenvorland	474	91
Sommerwarmer Osten	1,103	78
Mühl- und Waldviertel	1,225	96
Total	**11,345**	**96**

I3 Deadwood

Natural Forest Community	Standing dead-wood (m³/ha)	Lying dead-wood (m³/ha)	Target volume (m³/ha) 10% of total volume	Bio-diversity points
Larch – stone pine forest	5.24	13.88	23.1	81
Larch forest	9.13	15.17	26.7	91
Subalpine spruce forest	11.32	18.91	29.9	100
Montane spruce forest	6.99	14.87	32.0	68
Spruce – fir forest	7.58	13.14	37.2	56
Spruce – fir – beech forest	8.71	13.19	36.0	61
Beech forest	5.79	6.91	35.0	36
Oak – hornbeam forest	5.51	4.68	27.1	38
Acidophilous oak forest	2.05	3.19	28.2	19
Thermophilous oak forest	6.02	3.26	14.4	65
Scots pine – oak forest	1.99	4.16	32.4	19
Mixed lime forest	3.92	16.31	35.6	57
Sycamore forest	4.99	31.74	31.0	100
Sycamore – ash forest	5.13	13.29	30.2	61
Black alder – ash forest	5.32	6.19	28.2	41
Black alder forest marsh	3.42	6.19	22.4	43
Grey alder forest	4.57	15.87	15.6	100
Pine – birch – bogland forest	0.00	1.17	14.9	8
Calcareous Scots pine forest	9.49	4.90	24.1	60
Acidophilous Scots pine forest	7.83	9.86	27.1	65
Austrian black pine forest	5.57	2.77	28.4	29
Riparian poplar-willow forest	7.95	18.20	21.5	100
Riparian hardwood forest	5.44	5.80	18.7	60
Ash swamp forest	7.53	4.93	28.9	43

For this indicator it is obvious that high biodiversity points were scored in the natural regions “Innen- und Zwischen-alpen” and “Randalpen”. Outside these regions there is potenial for improvement.

Natural region	Number of AFI plots	Biodiversity points
Innen- und Zwischenalpen	3,785	66
Randalpen	4,759	68
Nördliches Alpenvorland	474	24
Sommerwarmer Osten	1,103	36
Mühl- und Waldviertel	1,225	21
Total	**11,346**	**58**

I4 Veteran trees

Alpine forest tree communities are characterized by relative high biodiversity points whilst especially in the ecoregion "Sommerwarmer Osten" and "Wald- und Mühlviertel" there is potential for improvement.

Natural forest community	Number of sample trees	Number of veteran trees	Biodiversity points
Larch – Stone pine forest	690	15	100
Pine forest	162	2	54
Subalpine spruce forest	6,396	147	100
Montane spruce forest	2918	34	73
Spruce – fir forest	9,689	60	42
Spruce – fir – beech forest	22,832	129	38
Beech forest	9,661	60	40
Oak – hornbeam forest	4,903	46	42
Acidophilous oak forest	674	7	47
Thermophilous oak forest	240	4	62
Scots pine – oak forest	859	4	16
Mixed lime forest	102	1	60
Sycamore forest	301	11	100
Sycamore – ash forest	1,317	14	42
Black alder – ash forest	887	12	46
Black alder forest marsh	226	1	31
Grey alder forest	349	2	92
Pine – birch – bogland forest	35	4	100
Calcareous Scots pine forest	525	25	100
Acidophilous Scots pine forest	242	8	100
Austrian black pine forest	99	6	100
Riparian poplar-willow forest	280	5	100
Riparian hardwood forest	284	1	22
Ash swamp forest	102	0	0
Natural forest community	**Number of sample trees**	**Number of veteran trees**	**Biodiversity points**
Innen- und Zwischenalpen	21,342	259	75
Randalpen	27,385	230	51
Nördliches Alpenvorland	2,586	27	60
Sommerwarmer Osten	5,366	50	40
Mühl- und Waldviertel	7,084	32	23
Total	**63,773**	**1,784**	**55**

I5 Presence of forest regeneration

Natural forest community	Number of AFI plots	Biodiversity points
Larch – stone pine forest	97	30
Larch forest	22	31
Subalpine spruce forest	686	34
Montane spruce forest	211	41
Spruce – fir forest	592	49
Spruce – fir – beech forest	1440	60
Beech forest	499	69
Oak – hornbeam forest	206	66
Acidophilous oak forest	32	56
Thermophilous oak forest	10	48
Scots pine – oak forest	25	70
Mixed lime forest	5	55
Sycamore forest	24	61
Sycamore – ash forest	63	59
Black alder – ash forest	16	41
Black alder forest marsh	8	53
Grey alder forest	17	53
Pine – birch – bogland forest	-	-
Calcareous Scots pine forest	53	42
Acidophilous Scots pine forest	20	53
Austrian black pine forest	8	53
Riparian poplar-willow forest	6	29
Riparian hardwood forest	13	23
Ash swamp forest	5	45
Natural region	**Number of AFI plots**	**Biodiversity points**
Innen- und Zwischenalpen	1,609	41
Randalpen	1,802	60
Nördliches Alpenvorland	122	64
Sommerwarmer Osten	237	66
Mühl- und Waldviertel	288	63
Total	**4,058**	**53**

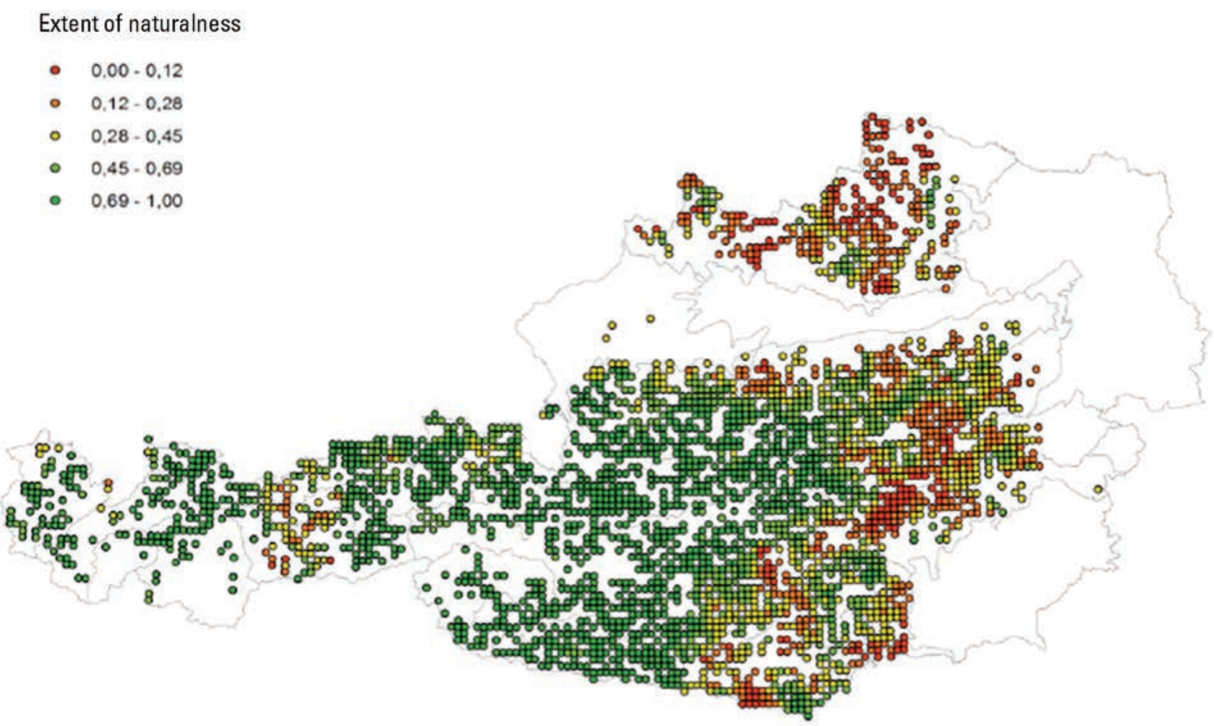
In the forest tree communities larch-stone, pine forest, larch forest and subalpine spruce forest which are mainly found in the natural region “Innen- und Zentralalpen” there are regeneration deficits.

I6 Regeneration type

It is striking that low biodiversity points were recorded in thermophilous oak forests and black alder forest marshes. However, number of AFI plots were extremely small for these natural forest communities which limits general conclusions.

Natural forest community	Number of AFI plots	Biodiversity points
Larch – stone pine forest	3	75
Larch forest	1	100
Subalpine spruce forest	59	72
Montane spruce forest	20	89
Spruce – fir forest	54	73
Spruce – fir – beech forest	160	85
Beech forest	55	76
Oak – hornbeam forest	22	68
Acidophilous oak forest	3	67
Thermophilous oak forest	1	25
Scots pine – oak forest	5	75
Mixed lime forest	-	-
Sycamore forest	3	92
Sycamore – ash forest	3	58
Black alder – ash forest	3	58
Black alder forest marsh	3	33
Grey alder forest	3	92
Pine – birch – bogland forest	-	-
Calcareous Scots pine forest	2	63
Acidophilous Scots pine forest	2	100
Austrian black pine forest	-	-
Riparian poplar-willow forest	1	75
Riparian hardwood forest	1	0
Ash swamp forest	1	100
Natural region	**Number of AFI plots**	**Biodiversity points**
Innen- und Zwischenalpen	128	70
Randalpen	201	89
Nördliches Alpenvorland	15	55
Sommerwarmer Osten	29	65
Mühl-und Waldviertel	32	73
Total	**405**	**78**

I7 Naturalness of the gene pool



Representation of the naturalness of the gene pool for Norway spruce; higher values equate to higher naturalness of the gene pool

Natural region	Number of observation points	Biodiversity points
Innen- und Zwischenalpen	1.393	81
Randalpen	1.306	69
Nördliches Alpenvorland	3	50
Sommerwarmer Osten	1	39
Mühl- und Waldviertel	305	37
Total	**3.008**	**71**

It is obvious that a low biodiversity value was found in the northern distribution area of Norway spruce.

I8 Forest fragmentation

-not yet determined-

I9 Browsing by game and livestock

This indicator has similar biodiversity points in all natural regions, however differs significantly among forest communities. It is striking that low values are present in the widely distributed spruce-fir-beech forest.

Natural forest community	Number of AFI plots	Biodiversity points
Larch – Swiss stone pine forest	65	35
Larch forest	12	47
Subalpine spruce forest	426	48
Montane spruce forest	185	68
Spruce – fir forest	191	47
Spruce – fir – beech forest	554	39
Beech forest	623	62
Oak – hornbeam forest	151	49
Acidophilous oak forest	33	62
Thermophilous oak forest	5	69
Scots pine – oak forest	60	52
Mixed lime forest	6	55
Sycamore forest	31	60
Sycamore – ash forest	156	59
Black alder – ash forest	49	52
Black alder forest marsh	4	100
Grey alder forest	28	65
Pine – birch – forest marsh	3	100
Carbonate pine forest	21	45
Silicate pine forest	11	87
Black pine forest	2	100
Poplar-willow riparian forest	2	80
Hardwood riparian forest	17	79
Ash swamp forest	11	78
Natural region	**Number of AFI plots**	**Biodiversity points**
Innen- und Zwischenalpen	803	49
Randalpen	1.293	52
Nördliches Alpenvorland	104	61
Sommerwarmer Osten	245	57
Mühl- Waldviertel	201	58
Total	**2.646**	**53**

I10 Natural forest reserves

Nr.	Natural forest communities (groups)	Forest community – ecoregion - combination			
		Included forest communities	Target value	Actual value	Degree of fulfillment*
		Quantity			%
1	High subalpine larch - Swiss stone pine forest	3	15	7	47
2	Larch forest	2	8	6	75
3	Deep subalpine spruce forest	4	51	23	45
4	Montane spruce forest	8	69	23	33
5	Spruce –fir forest	9	46	13	28
6	Spruce-fir-beech forest	9	48	22	46
7	High montane sycamore-beech forest	2	11	5	45
8	Beech forest	11	72	34	47
9	Oak – hornbeam forest	7	24	12	50
10	Subcontinental mixed oak forest	6	11	7	64
11	Acidophilous Scots pine – oak forest	4	25	8	32
12	Downy oak forest	5	9	3	33
13	Hop hornbeam – manna ash forest	1	4	3	75
14	Mixed lime forest	3	13	7	54
15	Sycamore- and sycamore-ash forest	7	52	20	38
16	Black alder - ash forest	5	29	9	31
17	Black alder forest marsh	2	19	2	11
18	Alder willow forest marsh	3	8	2	25
19	Grey alder forest	3	30	6	20
20	Riparian poplar-willow forest	8	36	5	14
21	Riparian hardwood forest	3	8	2	25
22	Acidophilous scots pine forest	3	11	6	55
23	Calcareous scots pine forest	2	13	8	62
24	Austrian black pine forest	2	3	2	67
25	Mountain pine forest	2	5	3	60
26	Scots pine – birch - mountain pine moorland forest	4	23	4	17
Total		**118**	**643**	**242**	**38**
*) disregarding minimum area requirements					
Biodiversity points (Degree of fulfilment x correction factor 1.5)					**57**

Comparatively low biodiversity points are found in the natural forest communities black alder forest marsh, riparian poplar-willow forest and Scots pine – birch – mountain pine moorland forest.

I11 Genetic reserve forests

Ecoregions 7 and 8 are not well covered by genetic reserve forests across most tree species. For certain species such as *Malus sylvestris*, *Populus nigra*, *Pyrus pyraster* and *Ulmus minor* no genetic reserve forests have been established yet.

Tree species	Main ecoregion	1	2	3	4	5	6	7	8	9	TAR-GET	Actual value
Silver fir *(Abies alba)*	High altitude											
	Mid altitude	●	●	●	●	●	●	●		●	8	7
	Low altitude	●	●	●	●	●	●	●	●	●	9	5
Field maple *(Acer campestre)*	High altitude											
	Mid altitude											
	Low altitude				●	●	●	●	●	●	6	2
Norway maple *(Acer platanoides)*	High altitude											
	Mid altitude		●	●	●	●	●			●	6	2
	Low altitude		●	●	●	●	●	●	●	●	8	4
Sycamore *(Acer pseudoplatanus)*	High altitude				●						1	0
	Mid altitude	●	●	●	●	●	●	●		●	8	6
	Low altitude	●	●	●	●	●	●	●	●	●	9	3
Black Alder *(Alnus glutinosa)*	High altitude											
	Mid altitude		●	●	●	●	●			●	6	0
	Low altitude		●	●	●	●	●	●	●	●	8	2
Grey Alder *(Alnus incana)*	High altitude											
	Mid altitude	●	●	●	●	●	●			●	7	5
	Low altitude	●	●	●	●	●	●	●	●	●	9	1
Hornbeam *(Carpinus betulus)*	High altitude											
	Mid altitude											
	Low altitude				●	●	●	●	●	●	6	6
Sweet chestnut *(Castanea sativa)*	High altitude											
	Mid altitude											
	Low altitude				●	●	●		●		4	2
Beech *(Fagus sylvatica)*	High altitude											
	Mid altitude	●	●	●	●	●	●	●		●	8	6
	Low altitude		●	●	●	●	●	●	●	●	8	6
Narrow leafed ash (Fraxinus angustifolia)	High altitude											
	Mid altitude											
	Low altitude								●		1	1
European ash *(Fraxinus excelsior)*	High altitude											
	Mid altitude	●	●	●	●	●	●	●		●	8	7
	Low altitude	●	●	●	●	●	●	●	●	●	9	7
Manna ash *(Fraxinus ornus)*	High altitude											
	Mid altitude						●				1	1
	Low altitude			●			●				2	0
European larch *(Larix decidua)*	High altitude	●	●	●	●	●	●				6	5
	Mid altitude	●	●	●	●	●	●			●	7	7
	Low altitude	●									1	0

Blue background: Reserve with this species exists.

Yellow background: Reserves exists, species with too small area percentage (expertly assessed).

Tree species	Main ecoregion	1	2	3	4	5	6	7	8	9	TAR-GET	Actual value
European crab apple *(Malus sylvestris)*	High altitude											
	Mid altitude											
	Low altitude					•			•		2	0
Hop hornbeam *(Ostrya carpinifolia)*	High altitude											
	Mid altitude					•	•				2	1
	Low altitude			•			•				2	0
Norway spruce *(Picea abies)*	High altitude	•	•	•	•	•	•			•	7	6
	Mid altitude	•	•	•	•	•	•	•		•	8	7
	Low altitude	•	•	•							3	3
Swiss pine *(Pinus cembra)*	High altitude	•	•	•	•		•				5	4
	Mid altitude	•	•	•							3	1
	Low altitude											
Mountain pine *(Pinus mugo ssp. uncinata)*	High altitude											
	Mid altitude		•		•					•	3	0
	Low altitude											
Black pine *(Pinus nigra ssp. austriaca)*	High altitude											
	Mid altitude					•	•				2	2
	Low altitude					•	•				2	1
Scots pine *(Pinus sylvestris)*	High altitude	•									1	1
	Mid altitude	•	•	•	•	•	•			•	7	7
	Low altitude	•	•	•	•	•	•	•	•	•	9	8
White poplar *(Populus alba)*	High altitude											
	Mid altitude											
	Low altitude					•	•	•	•	•	5	0
Black poplar *(Populus nigra)*	High altitude											
	Mid altitude											
	Low altitude		•	•	•	•	•	•	•	•	8	0
European wild pear *(Pyrus pyraster)*	High altitude											
	Mid altitude			•	•	•	•				4	0
	Low altitude		•	•	•	•	•	•	•	•	8	0
Turkey oak *(Quercus cerris)*	High altitude											
	Mid altitude											
	Low altitude				•	•			•		3	2
Sessile oak *(Quercus petraea)*	High altitude											
	Mid altitude	•		•	•	•	•			•	6	1
	Low altitude			•	•	•	•	•	•	•	7	6
Downy oak *(Quercus pubescens)*	High altitude											
	Mid altitude											
	Low altitude					•			•		2	0

Tree species	Main ecoregion	1	2	3	4	5	6	7	8	9	TAR-GET	Actual value
Pendunculate oak	High altitude											
(Quercus robur)	Mid altitude	•	•	•	•		•			•	6	1
	Low altitude	•	•	•	•	•	•	•	•	•	9	8
White willow	High altitude											
(Salix alba)	Mid altitude											
	Low altitude	•	•	•	•	•	•	•	•	•	9	0
Crack willow	High altitude											
(Salix fragilis)	Mid altitude									•	1	0
	Low altitude	•	•	•	•	•	•	•	•	•	9	0
Common whitebeam	High altitude											
(Sorbus aria)	Mid altitude	•	•	•	•	•	•				6	3
	Low altitude	•	•	•	•	•	•	•	•	•	9	3
True service tree	High altitude											
(Sorbus domestica)	Mid altitude											
	Low altitude					•			•		2	1
Wild service	High altitude											
(Sorbus torminalis)	Mid altitude											
	Low altitude				•	•		•	•	•	5	3
Yew	High altitude											
(Taxus baccata)	Mid altitude		•	•	•	•	•				5	5
	Low altitude		•		•	•	•	•		•	6	4
Small leaved lime	High altitude											
(Tilia cordata)	Mid altitude	•	•	•	•						4	1
	Low altitude	•	•	•	•	•	•	•	•	•	9	7
Large leaved lime	High altitude											
(Tilia platyphyllus)	Mid altitude		•	•	•	•	•				5	1
	Low altitude	•	•	•	•	•	•	•	•	•	9	6
Wych elm	High altitude											
(Ulmus glabra)	Mid altitude	•	•	•	•	•	•			•	7	6
	Low altitude	•	•	•	•	•	•	•	•	•	9	6
White elm	High altitude											
(Ulmus laevis)	Mid altitude											
	Low altitude							•	•		2	0
Field elm	High altitude											
(Ulmus minor)	Mid altitude											
	Low altitude					•		•	•	•	4	0
											361	**190**
Biodiversity points											**53**	

I12 Seed stands – optimising the use of available genetic resources

Results for the period 2003-2012:						
	Evenness of harvest (2003-2012)	**Domestic production conifers extracted from cone [kg]**	**Movement EU AT (minus Austrian origin) [kg]**	**Correction factor K_1 (percentage of domestic production from total use)**	**Weighting factor K_2**	**Biodiversity points reduced with K_1**
Norway Spruce	38,6	4714	42	0,99	0,50	38,3
Sycamore	26,1	8602	825	0,91	0,10	23,8
Beech	20,6	4230	516	0,89	0,10	18,4
Oak*	32,5	40177	8180	0,83	0,10	27,0
European Larch	22,4	5326	108	0,98	0,10	21,9
Silver Fir	43,6	5236	327	0,94	0,10	41,0
Biodiversity points: (weighted and rounded)						**32**

* *Quercus petraea, Quercus robur, Quercus rubra*

For all considered forest tree species the seed harvests were performed unevenly resulting into low biodiversity points. Moreover a substantial amount of forest reproductive material of sycamore and oaks are obtained from other countries.

I13 Conservation seed orchards

For this indicator comparatively low biodiversity points are obtained. For certain tree species such as *Acer platanoides*, *Taxus baccata* and *Quercus pubescens* no seed orchards have been established yet.

Species	Main ecoregion	1	2	3	4	5	6	7	8	9	TARGET	observed
Silver fir (*Abies alba*)	High altitude											
	Mid altitude		B[57]	C	D	E	F	G		H	8	5
	Low altitude								A			
Field maple (*Acer platanoides*)	High altitude											
	Mid altitude										2	0
	Low altitude				AB	A		B				
Norway maple (*Acer platanoides*)	High altitude											
	Mid altitude										3	0
	Low altitude				AB	A		B	C	B		
Sycamore (*Acer pseudoplatanus*)	High altitude											
	Mid altitude			G	H	I				J	10	5
	Low altitude			A	B	C	D	E	F			
Black alder (*Alnus glutinosa*)	High altitude											
	Mid altitude										4	2
	Low altitude		A	B			B		C	D		
Grey alder (*Alnus incana*)	High altitude											
	Mid altitude		A	A							1	1
	Low altitude											
Norway leaved ash (*Fraxinus angustifolia*)	High altitude											
	Mid altitude										1	0
	Low altitude								A			
Crab apple (*Malus sylvestris*)	High altitude											
	Mid altitude										2	0
	Low altitude				A	B	B	A	B	A		
Mountain pain (*Pinus uncinata*)	High altitude											
	Mid altitude				A						1	0
	Low altitude											
Wild pear (*Pyrus pyraster*)	High altitude											
	Mid altitude										2	1
	Low altitude				A	B	B	A	B	A		
Downy oak (*Quercus pubescens*)	High altitude											
	Mid altitude										1	0
	Low altitude					A			A			
True service tree (*Sorbus domestica*)	High altitude											
	Mid altitude										1	0
	Low altitude								A			

Status: 31.12.2015

[57] Every letter symbolises a plantation for a certain tree species. Where the same letter occurs more than once in a row, this means that the plantation covers more than one main ecoregion. Blue background signals: Plantation already established and harvested during the monitoring period. Yellow background signals: Plantation already established but not yet fructified or harvested during the monitoring period.

Every letter symbolises a plantation for a certain tree species. Where the same letter occurs more than once in a row, this means that the plantation covers more than one main ecoregion.

Blue background signals: Plantation already established and harvested during the monitoring period.

Yellow background signals: Plantation already established but not yet fructified or harvested during the monitoring period.

Species	Main ecoregion	1	2	3	4	5	6	7	8	9	TAR-GET	ob-served
Wild service tree *(Sorbus torminalis)*	High altitude											
	Mid altitude										2	2
	Low altitude				A				B			
Yew *(Taxus baccata)*	High altitude											
	Mid altitude				A						1	0
	Low altitude											
Wych elm *(Ulmus glabra)*	High altitude											
	Mid altitude										1	0
	Low altitude				A	A						
Field elm *(Ulmus minor)*	High altitude											
	Mid altitude										1	0
	Low altitude							A	A			
White elm *(Ulmus laevis)*	High altitude											
	Mid altitude										1	1
	Low altitude				A	A			A			
Total											**42**	**17**
Achieved percentage											**40.47 %**	
Biodiversity points											**40**	

Status: 31.12.2015

5. Aggregation of indicators

Based upon the values of the survey, the following results were scored for Austrian forests:

Indicator		Number of AFI plots	Biodiversity points (mean value commercial forests)	Weight (Survey)	MOBI-e
I1	Characteristic tree species of the PNFC	11,346	56	4	3
I2	Neophytic tree species	11,346	96	3	1
I3	Deadwood	11,346	58	5	5
I4	Veteran trees	11,346	55	4	2
I5	Presence of forest regeneration	4,058	53	4	3
I6	Regeneration type	405	78	3	2
I7	Naturalness of the gene pool		71	4	1
I8	Forest fragmentation		-		
I9	Browsing by game and livestock	2,646	53	4	3
I10	Natural forest reserves		57	4	4
I11	Genetic reserve forests		53	4	3
I12	Seed stands		32	3	1
I13	Conservation seed orchards		40	2	1
			Total:	**59**	**58**

The following values were scored for the natural regions:

The response indicators could not be evaluated for the natural regions, therefore the nationwide value was calculated for these indicators.

	Indicator	Innen- und Zwischen-alpen	Rand-alpen	Nördliches Alpen-vorland	Sommer-warmer Osten	Mühl-Wald-viertel	Weight
	I1	59	58	48	50	46	4
	I2	99	98	91	78	96	3
	I3	66	68	24	36	21	5
	I4	75	51	60	40	23	4
	I5	41	60	64	66	63	4
	I6	70	89	55	65	73	3
	I7	81	69	50	39	37	4
	I9	49	52	61	57	58	4
	I10	57	57	57	57	57	4
	I11	53	53	53	53	53	4
	I12	34	34	34	34	34	3
	I13	40	40	40	40	40	2
Biodiversity points (Total)		**61**	**61**	**53**	**51**	**49**	

6. Evaluations of previous AFI monitoring periods

Not for all indicators data from previous monitoring periods were available. However, when comparisons could be made biodiversity points normally increased.

6.1. Status and pressure indicators (AFI)

Data collected within the framework of the AFI are methodically comparable since 2000/2002. However, indicator 1 (characteristic tree species of the PNFC) and indicator 3 (dead wood) can only be approximately compared to the most recent data set. This limitation must be kept in mind when retrospecitve comparisons are made.

Table 1: Comparison AFI 2000/2002 and 2007/2009 Indicators 1-6 and 9

Production forest	I1		I2		I4		I5		I6	
	PNFC		Neophytic trees		Veteran trees		Presence of forest regeneration		Regeneration type	
	00/02	07/09	00/02	07/09	00/02	07/09	00/02	07/09	00/02	07/09
Innen- und Zwischenalpen	58	59	100	99	72	75	42	41	71	70
Mühl- Waldviertel	43	46	96	96	18	23	58	63	60	73
Randalpen	55	58	99	98	47	51	60	60	79	89
Nördliches Alpenvorland	48	48	92	91	56	60	61	64	71	55
Sommerwarmer Osten	51	50	82	78	29	40	66	66	75	65
Total	**54**	**56**	**97**	**96**	**51**	**55**	**53**	**53**	**74**	**78**
Larch- Swiss stone pine forest	73	74	100	100	100	100	35	30	98	75
Larch forest	64	59	100	100	29	54	37	31	--	--
Subalpine spruce forest	76	76	100	100	100	100	37	34	69	72
Montane spruce forest	76	78	100	99	77	73	48	41	67	89
Spruce – fir forest	48	49	100	100	43	42	49	49	66	73
Spruce – fir- beech forest	47	50	99	99	33	38	60	60	82	85
Beech forest	55	58	96	96	28	40	65	69	69	76
Oak – hornbeam forest	42	44	86	83	35	42	65	66	73	68
Acidophilous oak forest	48	50	85	89	26	47	42	56	100	67
Thermophilous oak forest	18	22	64	47	100	62	51	48	50	25
Scots pine – oak forest	51	53	94	93	47	16	71	70	75	75
Mixed lime forest	69	72	95	100	76	60	50	55		
Sycamore forest	46	57	99	100	100	100	49	61	100	92
Sycamore – ash forest	68	71	99	97	39	42	66	59	71	58
Black alder - ash forest/ash swamp forest	60	62	92	90	46	46	47	41	50	58
Black alder forest marsh	44	33	100	98	53	31	25	53	--	--
Grey alder forest	63	59	98	99	99	92	41	53	33	92
Pine - birch - bogland forest	63	63	92	100	100	100	--	--	--	--
Calcareous Scots pine forest	50	47	100	95	100	100	40	42	85	63
Acidophilous Scots pine forest	53	56	100	100	63	100	41	53	100	100
Austrian black pine forest	43	75	100	90	100	100	72	53		
Riparian softwood forest (poplar, willow)	70	43	74	73	53	100	43	29	100	75
Riparian willow forest		61		64	n.v.	22	--	--		--
Riparian mixed forest with oak – elm-ash	72	63	93	100	--	--	33	45		--
Ash forest	19		100				25			
Biodiversity points (Total)	**54**	**56**	**97**	**96**	**51**	**55**	**53**	**53**	**74**	**78**

6.2. Response indicators

6.2.1. Natural forest reserves (I10):

Period	Measured value	Target value	Degree of fulfillment	Biodiversity points
1996-2001	221	642	34,4	51
2001-2008	234	642	36,4	54
2008-2013	241	642	37,5	57

Test date: 30th June of the year

Test date 30.6.	Number NFRs	Total area (ha)
2001	172	8075
2008	194	8539
2013	195	8403

The establishment of six new reserves in the period 2008-2013 is contrasted by the closure of five older reserves . The total area was reduced during this period due to the closure of two large reserves.

6.2.2. Genetic reserve forests (I11):

	Measured value	Target value	Biodiversity
2001	182	361	50
2008	187	361	52
2013	190	361	53

7. Discussion and forecast

The AFBI was designed to be a comprehensive index. The predominant aim was to define important key functions for forest biodiversity and to provide good, resource-saving indicator data for a monitoring period. It must be emphasised here that the target values provided are not necessarily also target values according to environmental policy. The target values of the individual indicators merely serve to quantify the condition of biodiversity and, where appropriate, possibly enable the optimization of resources. However, the target values specify a desired final condition from a biodiversity point of view. With as few means as possible, the largest possible benefit, i.e. an improvement of the biodiversity status of forests, can be achieved. It must be mentioned here that at least theoretically a high realised forest biodiversity is attended by reduced conservation efforts. Means to conserve forest biodiversity will not longer be needed if the maximum status of biodiversity is present. In such a case all response indicators would be superfluous. For many indicators, a preferable final condition is erroneously not stated or cannot be quantified[58]. This is avoided through the creation of target values.

The target values are exclusively developed by scientific experts, however the results are always communicated to representatives from forest policy, lobby groups and forest managers[59]. The question of which political target values should be set for individual indicators and consequently also for the AFBI, is one that should be exclusively addressed in environmental and forest policy, respectively. The present approach (development of a concept and its first implementation) is merely an effective instrument for policy advice. During the creation of the concept and the first implementation, it was attempted to avoid further errors that frequently occur during the drafting of biodiversity indices.

Specific potentially achievable targets were set for the response indicators. That means a "management context" was produced which, for example, orientates itself to red listed species for the establishment of target values for conservation seed orchards. As already adhered to in the introduction, the indicators are weighted. The weighting of the indicators was carried out via online-survey on as broad a scientific basis as possible. The subjectivity of the evaluations is thereby unavoidable and always constitutes a part of the decision making process. In selecting the indicators, as well as the participants of the expert survey, it was however ensured that the various levels of biodiversity were as evenly represented as possible.

Surveys of political decision makers and forestry management (forest holdings exceeding a size of 500 ha) were also carried out, in order to uncover possible differences both between these groups and to the scientific experts (results were not presented in this

58 Failing, L., Gregory, R. (2003): Ten mistakes in designing biodiversity indicators for forest policy. Journal of Environmental Management 68: 121-132.

59 Nichols, J.D., Williams, B.K. (2006): Monitoring for conservation. Trends in Ecology and Evolution 21: 668–673.

report). It is worth mentioning here that there were only slight differences in regard to weighting between all surveyed groups.

It is unavoidable that in an index aggregated from individual indicators, such as the AFBI, that some important characteristics and regional differences in forest biodiversity remain indiscernible. An advantage of the AFBI reflects forest biodiversity for the whole country and is not based upon developments in certain sectors, for instance on changes of protected areas or species. Nevertheless, the advantages of an individual index - especially where communication to the wider public is concerned - are beyond dispute. A total value consisting of aggregated and weighted indicators, i.e. the AFBI, is for political decision makers and for the general public largely more attractive than long, partly confusing indicator lists with their somewhat contradictory developments. In general, the public is only concerned about whether the condition of forest biodiversity has changed in total and, where it has, to what degree. Details about individual species and their intraspecific diversity or the results of individual measures for the conservation or restoration of biodiversity are almost worthless at this level. Due to the scaling of the indicators and the total value of the AFBI between one and 100, trends can be communicated well. Inspired by the existing lists for forest-relevant indicators[60], the indicator lists for Austria were target oriented and kept as short as possible.

Most indicator values are based on data that was taken in the 5 – 7 year intervals of the AFI. As the AFBI can only record general trends, an extension of the interval for certain indicators would be conceivable. This is in contrast to the agricultural sector, wherein changes to biological diversity occur considerably quicker.[61]

With our approach, deficits in indicator based biodiversity monitoring should be remedied. For example, indicators are integrated which also target the preservation of genetic diversity of tree species. Special importance is thereby attached to natural reproduction and evaluation of the regeneration methods in managed forests (seed sources, usage of local seed sources, and usage of local seed bank plantations for rare tree species). This should complete as an indicator the simple declaration of seed sources and their areas as done within the framework of Forest Europe.

For the evaluation period 2007/2009 the AFBI reached approximately 60 points. If it is considered that index values close to 100 never can be achieved in multifunctional forests, the status of Austrian forests in regard to biodiversity must be assessed as good or even better. However, whilst reference values are crucial and indispensible for the whole concept, this approach is weak in communication to the general public. If a value is assessed by someone who is not familiar with whole concept, an AFBI of 60 points may be interpreted as mediocre. Hence, in order to avoid misinterpretation of the AFBI, future index values can be given as relative values based on the index value (2007/2009).

60 Larsson, T.-B., Angelstam, P., Balent, G., Barbati, A., Bijlsma, R.-J., Boncina, A., Bradshaw, R. et al. (2001): Biodiversity Evaluation Tools for European Forests. Ecological Bulletins, no. 50. Oikos Editorial Office: 1–237.

61 Abensperg-Traun, M., Wrbka, T., Bieringer, G., Hobbs, R., Deininger, F., Main, B.Y., Milasowszky, N., Sauberer, N., Zulka, K.P. (2004): Ecological restoration in the slipstream of agriculture agricultural policy in the old and new world. Agriculture, Ecosystems and Environment 103: 601-611.

Briefly summarised:

- The AFBI combines individual biodiversity aspects into one composite index.
- It defines clear target values for every indicator, the evaluation takes place on a scale of 0 to maximum of 100 achievable biodiversity points, thereby making the indicators comparable.
- The AFBI is predominantly based upon the quantifiable data of the Austria-wide, closely meshed forest inventory.
- The AFBI is a valuable instrument to inform a wide general audience, especially for policy makers and other stakeholders in the context of forest and biodiversity, while still having a high communicability to the general public.

The previous empirical foundation did not allow the target values to be denoted as absolute values. The index concept is however dynamic and adaptable, which means that all possible new scientific knowledge can be easily adapted, e.g. the ideal deadwood quantity from a biodiversity point of view. In the course of the further development of the index concept, the target values were intensively discussed, adapted and the evaluation scheme of some indicators were adjusted. Additionally every indicator for the AFI periods 2007 to 2009 was analysed and the results were aggregated according to their new weighting. Below, the individual indicators will be briefly discussed and necessary changes to the publicized concept proposal[62] will be introduced:

I1 Tree species of the potential natural forest communities (PNFC)

For this indicator the assessment scheme was adapted and differing evaluations were made, depending upon whether tree species of the PNFC occur as obligate or facultative species. Thereby the occurrence of one of the two "critical" tree species in the forest communities affected by the changes (spruce-fir-beech forest and spruce-fir forest) is better factored in.

I2 Neophytic tree species

The tree species which are to be considered neophytes were specified (Annex I, Table 2).

I3 Deadwood

The relative target value of 10 % of total standing volume and the evaluation scheme was retained. As already stated, the target value – if sound scientific findings for other suitable deadwood quantities exist – can also be adapted.

[62] Geburek, T., Milasowszky, N., Frank, G., Konrad, H., Schadauer, K. (2010): The Austrian forest biodiversity index: all in one. Ecological Indicators 10: 753-761.

I4 **Veteran trees**

For this indicator tree species and forest community specific minimum diameters were developed for the classification of veteran trees. The authors are aware that the diameter at breast height is only one characteristic of veteran trees. Unfortunately, the important aspect that - in an ideal situation - veteran trees will later become standing deadwood, can only be incompletely recorded by this indicator. At the present time, approximation via the diameter is the only possibility to record veteran trees as important prerequisites for a high biodiversity according to AFI data.

I5 **Presence of forest regeneration**

This indicator was developed so that only areas where regeneration was necessary[63] were observed. Additionally the evaluation scheme was changed.

I6 **Regeneration type**

With this indicator it must be noted, that only free standing regeneration areas and therefore only extremely few sample areas can be observed, which can then be used as a definitive starting point for the following stand.

I7 **Naturalness of the gene pool**

To date the only data available for this indicator is for Norway spruce. The indicator will only be used in the natural range of this forest tree species. It is obvious that this indicator would result into different biodiversity points when other forest tree species are considered. However, it can be expected that the gene pool of silver fir and beech has been little affected by humans. Compared to many other European countries the gene pool of forest tree species is probably less altered in Austria.[64]

I8 **Forest fragmentation**

To calculate this indicator, a basic data in the necessary quality (forest map with 1m resolution from laser scanning data and aerial photographs) is still under construction and should be available in 2017 at the earliest.

I9 **Browsing by game and livestock**

The methods and evaluation scheme were changed. The area-wide browsing damage of present regeneration and the restricting factors of pasture and browsing damage on not present regeneration will be monitored. One weakness of this indicator is the difficulty in differentiating between browsing damage by livestock and game, even if the strength of the impact of game on forest regeneration is already

63 According to the AFI (unstocked areas, juvenile trees, trees in the final fifth of rotation time)

64 Cf. Jansen, S., Geburek, Th. (2016): Historic translocations of European Larch (*Larix decidua* Mill.) genetic resources across Europe – a review starting from the 17th century. Forest Ecology and Management 379 : 114-123.

known through relevant studies[65] and game impact monitoring[66].

I10 **Natural forest reserves**
As a complete degree of fulfilment is not realistic, the indicator is amended with a correction factor. This allows the monitoring and evaluation methods to be adapted to the real conditions.

I11 **Genetic reserve forests**
The tree species selection was discussed and target values for genetic reserve forests redefined. Of the 22 growth areas, only the nine main growth areas will be included in terms of applicability. Altitudes were amalgamated in altitude zones. These adaptations were made in order to maintain the practicability of the indicator.

I12 **Seed stands – optimising the use of available genetic resources**
The methods to measure the evenness of the seed harvest were developed further. The values were recorded for the tree species Norway spruce, fir, larch, beech, sycamore and oak species. In the calculation, the proportion of moved forest reproductive material is also taken into account. The repeated harvest of a seed stand within one year is presently only indirectly included in the evaluation (via possibly high quantities).

I13 **Conservation seed orchards**
For this indicator, target values for the main growth areas and altitude zones were redefined by expert assessment.

Supplementation through further indicators

The integration of further indicators is generally possible and can contribute – where basic data and compatibility are available – to an improvement of the approach. A considerable and often unfulfilled requirement is the specification of relevant target values. To what extent the concept can therefore be extended to, for example birds and lichens, needs to be tested for each individual case.

The Woodland-Bird-Index[67] at least in its present form cannot be combined with the AFBI, as this bird indicator does not contain target values. Discussion should however be encouraged about whether through the Austrian breeding birds atlas a “bird indicator” can be developed that is compatible with the AFBI.

Similarly, a “lichen indicator” might be developed. The suitability of lichens as biological indicators is recognized amongst the

[65] El Kateb, H., Stolz, M., Mosandl, R. (2009): Der Einfluß von Wild and Weidevieh auf die Verjüngung im Bergmischwald. LWF aktuell 71: 16-18.
[66] http://www.wildeinflussmonitoring.at/
[67] Büchsenmeister, R. (2014): Der Waldvogel-Indikator für Österreich – Das Gegenstück zum Farmland Bird Index für den Wald. Ländlicher Raum 3: 1-22.

specialist community. However for their inclusion in the index concept, Austria-wide area wise data for lichens must be available. Relevant target values for the various regions of Austria are also non-existent. An approach via additional measurements of selected lichen species in the AFI would however be a possibility in principle.

The data necessary for determination are based upon the AFI, forest genetic inventory results, the natural forest reserve programme, measurements of genetic reserve forests, data from the Federal Forest Office, and from the BMLUFW Plantation Programme. The acquisition of information for the AFBI is therefore only realized in the future, if the relevant data measurement is continuously repeated.

8. Summary

Forest biodiversity cannot be exactly recorded or even measured in its entirety. The "**Austrian Forest Biodiversity Index (AFBI)"** presented here, which is based upon a proposal already published by BFW[68], allows the **biodiversity in Austrian forests** to be **approximately described** via selected status, pressure, and response indicators. All indicators are aggregated into one index. There was a conscious attempt to appropriately consider **all levels of biodiversity** (genetic diversity, species and ecosystem diversity). The AFBI was conceptually developed further in this report and **up-to-date** and **retrospective values of the AFBI** were calculated.

The **single indicator target values** compiled from a biodiversity research perspective, and their **weighting** play a **central role** in the development of the AFBI[69]. It can therefore be directly assessed which degree of fulfilment exists and how closely the present situation in the forest corresponds to an optimal situation for biodiversity. It is thereby possible to better assess measures for the protection or improvement of biodiversity in terms of their efficiency. All single indicators as well as the AFBI as an aggregated index are standardised on a scale of 0 to 100 biodiversity points. In this way the **total biodiversity condition** in forests can be **approximately indicated with one measurement value.** Possible changes have a **very high immediate value** for **policy consultations.** For this reason the obtaining of the otherwise relevant specialist expertise (*ex post*) to assess a change to an indicator and/or to weight various influencing factors is unnecessary, and the political decision makers are not themselves obliged to assess the development of indicators overall. It must however be especially emphasised, that the target values compiled from a biodiversity research perspective **do not represent target values for environmental or forest policy.**

The AFBI is based exclusively on data which are already available at national level, and aims to be primarily applicable at national level, but can also deliver valuable indications to political decision makers at a regional level. For this reason a **pragmatic approach** was consciously taken; so that the feasible rather than the desirable - from a federal research perspective - was the maxim during the concept development.

For the entire national territory an AFBI of ca. **60 points** was calculated. **This value can be considered as (very) high.** The calculated index in the "Randalpen" and the "Innenalpen" is especially high, in the Waldviertel and Mühlviertel the AFBI is relatively lower, and the other regions of Austria scored mid-range values. For almost all indicators an assessment over a longer period of time (ca. 20 years) was possible. Unfortunately no data from the Federal Forest Office was available for the indicator "Seed stands" – optimizing the use of available genetic resources. Therefore only certain single indicators

[68] Geburek, T., Milasowszky, N., Frank, G., Konrad, H., Schadauer, K. (2010): The Austrian forest biodiversity index: all in one. Ecological Indicators 10: 753-761.

[69] Failing, L., Gregory, R. (2003): Ten mistakes in designing biodiversity indicators for forest policy. Journal of Environmental Management 68: 121-132.

reflect forest biodiversity development over two decennia. Retrospectively, from the remaining 12 indicators for which relevant data was available, ten had improved, one had worsened (indicator "browsing by game and livestock") and the indicator "presence of forest regeneration" showed no change.

A **communication-strong concept** for the condition and development of forest biodiversity is available, which is of great benefit for political consultation and also for a wider audience. Furthermore, the latest developments in biodiversity research can be directly taken into account via the weighting of indicators and the setting of target values respectively, and AFBI calculations can be made directly comparable. Thereby, the methodical requirements for the development of a continuous monitoring of Austrian forest biodiversity are met.

9. Annex I: Tables

Table 1:
Tree species of the potential natural forest communities.

Potential Natural Vegetation (PNV)	PNV characteristic tree species	Potential Natural Vegetation (PNV)	PNV characteristic tree species
Larch- Swiss stone pine forest	Swiss stone pine or Larch	Black alder – ash forest	Black alder or Ash
Larch forest	Larch	Black alder forest marsh	Black alder
Subalpine spruce forest	Norway spruce	Grey alder forest	Grey alder
Montane spruce forest	Norway spruce	Mountain pine forest	Mountain pine
Spruce – fir forest	Norway spruce and Fir	Swiss mountain pine forest	Swiss mountain pine
Spruce – fir- beech forest	Norway spruce and Fir and Beech	Scots pine – birch forest marsh	Scots pine or Downy birch
Beech forest	Beech	Calcareous scots pine forest	Scots pine
Oak – hornbeam forest	Sessile oak or Common oak and Hornbeam	Acidophilous scots pine forest	Scots pine
Acidophilous oak forest	Sessile oak or Common oak	Black pine forest	Black pine
Thermophilous oak forest	Downy oak or Turkey oak	Riparian softwood forest (poplar, willow)	Black poplar or Grey alder or Silver poplar or White willow or Bruchweide
Scots pine – oak forest	Sessile oak or Common oak	Riparian willow forest	White willow or Bruchweide or Black poplar
Mixed lime forest	Large leaved lime or Small leaved lime or Norway maple or Ash	Riparian mixed forest with oak – elm-ash	Ash or Narrow leaved Ash or Common oak or Field elm or White elm
Sycamore forest	Sycamore	Ash forest	Black alder or Ash
Sycamore – ash forest	Sycamore or Ash	Green alder	Green alder

Table 2:
Neophytic tree species (according to AFI)

Tree species		Tree species	
Acer negundo	Boxelder	*Pinus strobus*	Strobe pine
Aesculus hippocastaneum	Horse chestnut red, white	*Platanus spp.*	Plane species
Ailanthus altissima	Tree of heaven	*Populus balsamifera*	Balsam poplar
Celtis spp.	Nettle tree	*Populus x canadensis*	Hybrid black poplar
Fraxinus pennsylvanica	Green Ash	*Pseudotsuga menziesii*	Douglas fir
Gleditsia triacanthos	Honey locust	*Quercus rubra*	Northern red oak
Juglans nigra	Eastern black walnut	*Robinia pseudoacacia*	Black locust
Morus spp.	Mulberry black, white		

Table 3:
Minimum diameter at breast height for veteran trees of PNV characteristic tree species

	Abies alba	*Acer spec.*	*Alnus glutinosa*	*Alnus incana*	*Betula spec.*	*Carpinus betulus*	*Castanea sativa*	*Fagus sylvatica*	*Fraxinus spec.*	*Juglans regia*	*Larix decidua*	*Malus spec. / Pyrus spec.*	*Ostrya carpinifolia*	*Picea abies*	*Pinus cembra*
Larch - Stone Pine forest		70									70			65	75
Larch forest	65	70			40			65			65			65	65
Subalpine spruce forest	65	70		35	40			75			70			65	75
Montane spruce forest	70	70		35	40			75			75			70	75
Spruce - fir forest	75	70	50	35	40			75	70		75			75	75
Spruce - fir - beech forest	75	70	50	35	40	60	80	75	70	45	75	35		75	
Beech forest	75	70	50	35	40	60	80	75	75	45	75	35	40	75	
Oak - hornbeam forest	75	50	50		40	60	80	75	60	45	75	35		75	
Acidophilous oak forest/scots pine - oak forest	60	45			40	40	65	60	60		60	30		60	
Thermophilous oak forest		45			40	40	50	50	45	45	60	30	45	60	
Mixed lime forest	60	60	40	35	40	60	65	60	60	45	60	35		60	
Sycamore forest/sycamore - ash forest	75	70	50	35	40	60		75	70	45	75	35		75	
Black alder - ash forest/ash swamp forest	75	70	50	35	40	60	65	75	80			45		75	
Black alder forest marsh	70		50	35	40				70					70	
Grey alder forest	75	70	40	35	40				70		75			75	
Pinus unicanta forest	60										75			60	
Mountain pine forest											75			60	75
Pine - birch - bogland forest			40		40									60	
Calcareous Scots pine forest	60							60	45		60		40	60	
Acidophilous Scots pine forest	60	45			40		50	60	45		60			60	
Austrian black pine forest								60	45			25	40	60	
Riparian poplar forest		50		35	40				70	45		45		75	
Riparian willow forest			50	35					70					75	
Riparian hardwood forest		60	50	35	40	60			80	45		45		75	
Green alder forest		70									75			75	75

Table 3:
Minimum diameter at breast height for veteran trees of PNV characteristic tree species

	Pinus nigra	*Pinus silvestris*	*Pinus uncinata*	*Populus alba*	*Populus nigra*	*Populus tremula*	*Prunus avium*	*Quercus spec.*	*Salix spec.*	*Sorbus spec./ prunus spec.*	*Sorbus torminalis*	*Taxus baccata*	*Tilia spec.*	*Ulmus spec.*
Larch - Stone Pine forest		65								20				
Larch forest										20				
Subalpine spruce forest		65								20				
Montane spruce forest		65	25			50			50	25				
Spruce - fir forest	65	65				50	45	80	50	25		40	70	60
Spruce - fir - beech forest	65	65				50	45	80	50	25		40	70	60
Beech forest	65	65		70		50	65	80	50	30	40	40	70	60
Oak - hornbeam forest	65	65		70	100	50	65	80	50	30	40	40	60	50
Acidophilous oak forest/scots pine - oak forest	55	55				50		65	50	30	30	30	50	
Thermophilous oak forest	45	45				50	45	50		30	30		45	40
Mixed lime forest	65	65				50	65	65		30		30	60	50
Sycamore forest/sycamore - ash forest	65	65				50	65	80	50	25		40	70	60
Black alder - ash forest/ash swamp forest		65			100	70	65	80	75	30			70	60
Black alder forest marsh		65						80	75	30				
Grey alder forest		65		70	70	60		80	75	30				60
Pinus unicanta forest		40	25							25		30		
Mountain pine forest			25							25				
Pine - birch - bogland forest		40						50		20				
Calcareous Scots pine forest	45	45								25				
Acidophilous Scots pine forest	55	55						50		25				
Austrian black pine forest	45	45						50		25				
Riparian poplar forest		65		75	100		65	80	75	30				60
Riparian willow forest				75	100				75	30				
Riparian hardwood forest		65		75	100	70	65	80	75	30			70	60
Green alder forest										20				

Table 4:
Minimum plant number for the presence of regeneration[70]

Plant height	Minimum plant number	
	Undivided sample area 10/10	Divided sample area 1/10
130 cm	10	1
120 cm	11	1
110 cm	12	1
100 cm	13	1
90 cm	14	1
80 cm	15	2
70 cm	17	2
60 cm	19	2
50 cm	21	2
40 cm	25	3
30 cm	30	3
20 cm	50	5
10 cm	150	15

70 For further details about regeneration measurement see Hauk, E., Schadauer, K. (2009): Instruktionen zur Feldarbeit der Österreichischen Waldinventur 2007-2009, Pkt. 7.13.

Table 5:
Target values for natural forest reserves

Natural forest vegetation (groups)[71]	Forest community-ecoregions -combinations	
	Quantity	
	Included forest communities	Target value
High subalpine larch - Swiss stone pine forest	3	15
Larch forest	2	8
Subalpine spruce forest	4	51
Montane spruce forest	8	69
Spruce –fir forest	9	46
Spruce-fir-beech forest	9	48
High montane sycamore-beech forest	2	11
Beech forest	11	72
Oak – hornbeam forest	7	24
Subcontinental mixed oak forest	6	11
Acidophilous Scots pine – oak forest	4	25
Downy oak forest	5	9
Hop hornbeam – manna ash forest	1	4
Mixed lime forest	3	13
Sycamore- and sycamore-ash forest	7	52
Black alder - ash forest	5	29
Black alder forest marsh	2	19
Alder willow forest marsh	3	8
Grey alder forest	3	30
Riparian poplar-willow forest	8	36
Riparian hardwood forest	3	8
Acidophilous scots pine forest	3	11
Calcareous scots pine forest	2	13
Austrian black pine forest	2	3
Mountain pine forest	2	5
Scots pine – birch - mountain pine moorland forest	4	23
Total result	**118**	**643[72]**

[71] The repeatedly described natural forest communities in this document actually refer to forest community groups, which include various forest communities. For better legibility, the common description "natural forest community" is retained.

[72] This figure does not necessarily represent the number of natural forest reserves, as in a natural forest reserve more than one forest community – ecoregion combination can exist.

Table 6: Target values for genetic reserve forests.[73]

Table 6-1:
Target values for genetic reserve forests.[73]

Tree species	Eco-region	1	2	3	4	5	6	7	8	9
Silver Fir *(Abies alba)*	High altitude[74]									
	Mid altitude	•[75]	•	•	•	•	•	•		•
	Low altitude	•	•	•	•	•	•	•	•	•
Field maple *(Acer campestre)*	High altitude									
	Mid altitude									
	Low altitude				•	•	•	•	•	•
Norway maple *(Acer platanoides)*	High altitude									
	Mid altitude		•	•	•	•	•			•
	Low altitude		•	•	•	•	•	•	•	•
Sycamore *(Acer pseudoplatanus)*	High altitude				•					
	Mid altitude	•	•	•	•	•	•	•		•
	Low altitude	•	•	•	•	•	•	•	•	•
Black alder *(Alnus glutinosa)*	High altitude									
	Mid altitude		•	•	•	•	•			•
	Low altitude		•	•	•	•	•	•	•	•
Grey alder *(Alnus incana)*	High altitude									
	Mid altitude	•	•	•	•	•	•			•
	Low altitude	•	•	•	•	•	•	•	•	•
Hornbeam *(Carpinus betulus)*	High altitude									
	Mid altitude									
	Low altitude				•	•	•	•	•	•
Sweet chestnut *(Castanea sativa)*	High altitude									
	Mid altitude									
	Low altitude				•	•	•		•	
Beech *(Fagus sylvatica)*	High altitude									
	Mid altitude	•	•	•	•	•	•	•		•
	Low altitude		•	•	•	•	•	•	•	•
Narrow-leaved ash *(Fraxinus angustifolia)*	High altitude									
	Mid altitude									
	Low altitude								•	
Common ash *(Fraxinus excelsior)*	High altitude									
	Mid altitude	•	•	•	•	•	•	•		•
	Low altitude	•	•	•	•	•	•	•	•	•
Manna ash *(Fraxinus ornus)*	High altitude									
	Mid altitude						•			
	Low altitude			•			•			
European larch *(Larix decidua)*	High altitude	•	•	•	•	•	•			
	Mid altitude	•	•	•	•	•	•			•
	Low altitude	•								

73 It would be fundamentally desirable to compile all tree species native to Austria in a sufficiently large number of genetic reserve forests. However, the differentiation between "trees" and "shrubs" is fluid, whereby the characteristic of a tree species is on the one hand a minimum height of between 5 and 8 meters, and on the other hand the presence of a single main stem. The hazelnut (*Corylus avellana*) can therefore reach a height of up to 10 metres, but as it has a multiple stems it is considered a shrub. Some species, which can display tree-like growth but mostly grow as shrubs are not included in this table. This includes for example Juniper (*Juniperus communis*), the oneseed hawthorn (*Crataegus monogyna*) or the bird cherry (*Prunus padus*).

74 High altitude: high subalpine, deep subalpine; Mid altitude: high montane, mid montane, deep montane; Low altitude: sub montane, Collin / planar.

75 Every point refers to one forest genetic reserve.

Table 6-2:
Target values for genetic reserve forests.

Tree species	Eco-region	1	2	3	4	5	6	7	8	9
Crab apple *(Malus sylvestris)*	High altitude									
	Mid altitude									
	Low altitude					•			•	
Hop hornbeam *(Ostrya carpinifolia)*	High altitude									
	Mid altitude					•	•			
	Low altitude			•			•			
Norway spruce *(Picea abies)*	High altitude	•	•	•	•	•	•			•
	Mid altitude	•	•	•	•	•	•	•		•
	Low altitude	•	•	•						
Swiss stone pine *(Pinus cembra)*	High altitude	•	•	•	•		•			
	Mid altitude	•	•	•						
	Low altitude									
Mountain pine *(Pinus mugo ssp. uncinata)*	High altitude									
	Mid altitude		•		•					•
	Low altitude									
Austrian black pine *(Pinus nigra ssp. austriaca)*	High altitude									
	Mid altitude					•	•			
	Low altitude					•	•			
Scots pine *(Pinus sylvestris)*	High altitude	•								
	Mid altitude	•	•	•	•	•	•			•
	Low altitude	•	•	•	•	•	•	•	•	•
Silver poplar *(Populus alba)*	High altitude									
	Mid altitude									
	Low altitude					•	•	•	•	•
Black poplar *(Populus nigra)*	High altitude									
	Mid altitude									
	Low altitude		•	•	•	•	•	•	•	•
Wild pear *(Pyrus pyraster)*	High altitude									
	Mid altitude			•	•	•	•			
	Low altitude		•	•	•	•	•	•	•	•
Turkey oak *(Quercus cerris)*	High altitude									
	Mid altitude									
	Low altitude				•	•			•	
Sessile oak *(Quercus petraea)*	High altitude									
	Mid altitude	•		•	•	•	•			•
	Low altitude			•	•	•	•	•	•	•
Downy oak *(Quercus pubescens)*	High altitude									
	Mid altitude									
	Low altitude					•			•	

Table 6-3:
Target values for genetic reserve forests.

Tree species	Eco-region	1	2	3	4	5	6	7	8	9
Common oak (*Quercus robur*)	High altitude									
	Mid altitude	•	•	•	•		•			•
	Low altitude	•	•	•	•	•	•	•	•	•
White willow (*Salix alba*)	High altitude									
	Mid altitude									
	Low altitude	•	•	•	•	•	•	•	•	•
Crack willow (*Salix fragilis*)	High altitude									
	Mid altitude									•
	Low altitude	•	•	•	•	•	•	•	•	•
Whitebeam (*Sorbus aria*)	High altitude									
	Mid altitude	•	•	•	•	•	•			
	Low altitude	•	•	•	•	•	•	•	•	•
Service tree (*Sorbus domestica*)	High altitude									
	Mid altitude									
	Low altitude					•			•	
Wild service tree (*Sorbus torminalis*)	High altitude									
	Mid altitude									
	Low altitude				•	•		•	•	•
Yew (*Taxus baccata*)	High altitude									
	Mid altitude		•	•	•	•	•			
	Low altitude		•		•	•	•	•		•
Small leaved lime (*Tilia cordata*)	High altitude									
	Mid altitude	•	•	•	•					
	Low altitude	•	•	•	•	•	•	•	•	•
Large leaved lime (*Tilia platyphyllus*)	High altitude									
	Mid altitude		•	•	•	•	•			
	Low altitude	•	•	•	•	•	•	•	•	•
Wych elm (*Ulmus glabra*)	High altitude									
	Mid altitude	•	•	•	•	•	•			•
	Low altitude	•	•	•	•	•	•	•	•	•
White elm (*Ulmus laevis*)	High altitude									
	Mid altitude									
	Low altitude							•	•	
Field elm (*Ulmus minor*)	High altitude									
	Mid altitude									
	Low altitude					•		•	•	•
Total										**361**

Table 7-1:
Target values for conservation seed orchards

Tree species	Eco-region	1	2	3	4	5	6	7	8	9	Target value
Silver Fir *(Abies abies)*	High altitude										
	Mid altitude		A[76]	B	C	D	E	F		G	8
	Low altitude								H		
Field maple *(Acer campestre)*	High altitude										
	Mid altitude										2
	Low altitude				AB	A		B			
Norway maple (*Acer platanoides*)	High altitude										
	Mid altitude										3
	Low altitude				AB	A		B	C	B	
Sycamore *(Acer pseudoplatanus)*	High altitude										
	Mid altitude			G	H	I				J	10
	Low altitude			A	B	C	D	E	F		
Black alder *(Alnus glutinosa)*	High altitude										
	Mid altitude										4
	Low altitude		A	B			B		C	D	
Grey alder *(Alnus incana)*	High altitude										
	Mid altitude		A	A							1
	Low altitude										
Narrow-leaved ash *(Fraxinus angustifolia)*	High altitude										
	Mid altitude										1
	Low altitude								A		
Crab apple *(Malus sylvestris)*	High altitude										
	Mid altitude										2
	Low altitude				A	B	B	A	B	A	
Mountain pine *(Pinus uncinata)*	High altitude										
	Mid altitude				A						1
	Low altitude										
Wild pear *(Pyrus pyraster)*	High altitude										
	Mid altitude										2
	Low altitude				A	B	B	A	B	A	
Downy oak *(Quercus pubescens)*	High altitude										
	Mid altitude										1
	Low altitude					A			A		
Sevice tree *(Sorbus domestica)*	High altitude										
	Mid altitude										1
	Low altitude								A		
Wild service tree *(Sorbus torminalis)*	High altitude										
	Mid altitude										2
	Low altitude				A				B		

[76] Every letter symbolises a plantation for a specific tree species. Where the same letter appears for a tree species multiple times in one row, the orchard covers more than one ecoregion.

Tabelle 7-2:
Target values for conservation seed orchards

Tree species	Eco-region	1	2	3	4	5	6	7	8	9	Target value
Yew *(Taxus baccata)*	High altitude										
	Mid altitude				A						1
	Low altitude										
Wych elm *(Ulmus glabra)*	High altitude										
	Mid altitude										1
	Low altitude				A	A					
White elm *(Ulmus laevis)*	High altitude										
	Mid altitude										1
	Low altitude							A	A		
Field elm *(Ulmus minor)*	High altitude										
	Mid altitude										1
	Low altitude				A	A			A		
Total											**42**

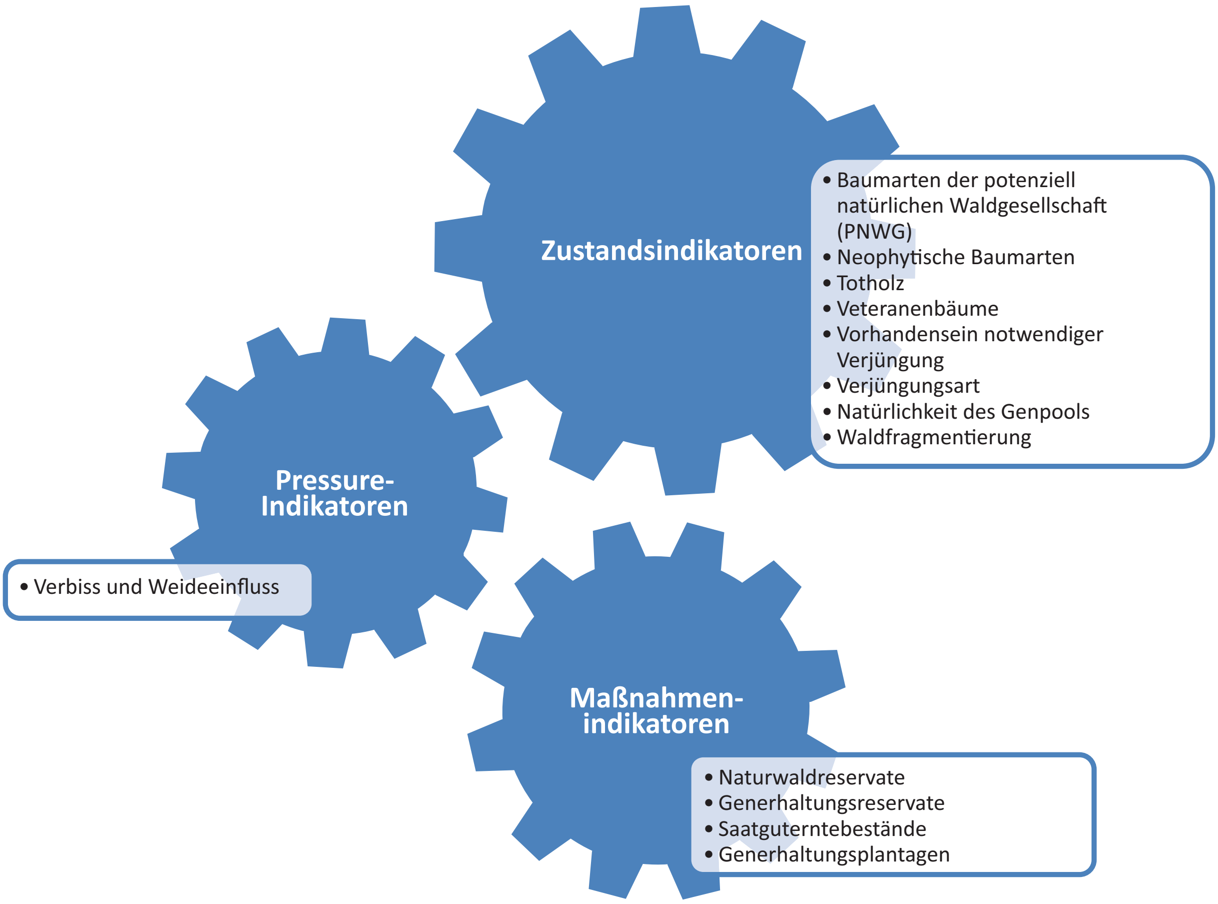
10. Annex II: Additional information

10.1. Weighting of indicators – Expert survey (screenshots)

Here screenshots of the online survey are presented. Please note, that exclusively German speaking experts in Austria, Germany and Switzerland were contacted and therefore the screenshots are in German.

Die in diesem Ansatz verwendeten Indikatoren dienen als Werkzeuge, um Waldbiodiversität zu qualifizieren. Der Index setzt sich aus **acht Zustandsindikatoren, einem Pressure-Indikator und vier Maßnahmenindikatoren** zusammen.

Es handelt sich bei dem Index um ein Konzepte, dass aus wertvollen, **bereits vorhandenen Daten** - die größtenteils aus der **Österreichischen Waldinventur** stammen - Waldbiodiversität in Österreich bestmöglich beschreiben soll. Es wurden daher nur solche Indikatoren gewählt, für die **Referenzwerte** definiert werden konnten und für die eine **Datenbasis vorhanden** ist oder derzeit erarbeitet wird. Aus diesem Grund sind einige für Waldbiodiversität ebenfalls relevante Größen wie z.B. die vertikale und horizontale Waldstruktur oder das Vorhandensein spezieller Zeigerarten (Flechten, Vögel, ...) nicht berücksichtigt worden.



Indicators of the forest biodiversity index

Gewichtung der Indikatoren

Welche Priorität hat der jeweilige Indikator für die Erhaltung von Waldbiodiversität?

Die Indikatoren werden für den Biodiversitätsindex Wald zu einem Gesamtwert aggregiert. Die Indikatoren gehen dabei mit unterschiedlicher Gewichtung in die Geamtwertung ein. Ihre Einschätzung der Priorität bzw. der Bedeutung einzelner Indikatoren ist für die Weiterentwicklung des Index von wesentlicher Bedeutung.

Informationen zu den Indikatoren erhalten Sie durch Anklicken der grau hinterlegten Indikatorenbezeichnung.

		sehr wenig Priorität	wenig Priorität	mittlere Priorität	hohe Priorität	sehr hohe Priorität
		1	2	3	4	5
Indikator 01:	Baumarten der Potenziell natürlichen Waldgesellschaften	○	○	○	○	○
Indikator 02:	Neophytische Baumarten	○	○	○	○	○
Indikator 03:	Totholz	○	○	○	○	○
Indikator 04:	Veteranenbäume	○	○	○	○	○
Indikator 05:	Vorhandensein notwendiger Verjüngung	○	○	○	○	○
Indikator 06:	Verjüngungsart	○	○	○	○	○
Indikator 07:	Natürlichkeit des Genpools	○	○	○	○	○
Indikator 08:	Waldfragmentierung	○	○	○	○	○
Indikator 09:	Verbiss und Weideeinfluss	○	○	○	○	○
Indikator 10:	Naturwaldreservate	○	○	○	○	○
Indikator 11:	Generhaltungsreservate	○	○	○	○	○
Indikator 12:	Saatguterntebestände	○	○	○	○	○
Indikator 13:	Generhaltungsplantagen	○	○	○	○	○

Weighting of indicators

10.2. AFI data

The analysis of the indicators 1-6 and 9 are based upon data from the AFI. This has been undertaken since 1961 on a systematic sample plot network in Austrian forests. In 1981 the sample points were permanently but invisibly marked and have since then been periodically visited. Besides economic indicators, numerous ecological parameters are measured at these sample areas, which have been used for this analysis. The calculation of the indicators I1, I2, I5, I6 and I9 is carried out at every sample area separately for the various analysis-strata and from this the relevant mean values are formed. I3 (deadwood) and I4 (veteran trees) are calculated as a proportion of the standing volume per hectare and the stand area for larger strata respectively. The evaluations refer to production forests (commercial forests and protective forests in yield). For the accessible protective forest without yield (298,000 ha or 7.4% of the Austrian forest area), there can be no calculation of the indicators due to the inadequate number of evaluable sample areas and the lack of measurement data for sample trees. Further details of the measurement method of the Austrian Forest Inventory can be read in the handbook (German language) (http://bfw.ac.at/700/pdf/DA_2009_Endfassung_klein.pdf).

10.3. Annotation: Indicator I12: Seed stands – optimising the use of available genetic resources

In order to estimate the evenness measure[77] the minimum seed quantity that realistically is harvested for a certain tree species in a certain year must be known. This seed quantity is forest tree species specific as seed weight, yield, and problems encountered in the course of seed harvests vary among species. For instance it is perspicuous that a seed harvest implemented within the framework of a timber harvest is less expensive than seed harvests for which trees have to be climbed up. For each forest tree species the lower quartile of the seed quantity of the whole monitoring period is estimated. Then the yearly seed harvest for each forest tree species is divided by the respective quartile and results into a number (to be rounded up to the next integral number) of seed stands that theoretically were optimal. The yearly seed harvest is then divided by this integral number and results into a theoretical seed quantity per seed stand which is related to the total yearly seed quantity. Both this proportion as well as the proportion obtained from an evenly distributed seed harvest is then used to calculate the evenness measure.

This yearly measure can vary between zero (no evenness) and one (complete evenness). As yearly seed harvests vary the yearly evenness measure is weighted with the yearly seed quantity and finally averaged over the monitoring period. The measures are estimated for six forest tree species (Norway spruce, silver fir, European larch, beech, sycamore and oaks[78]. The averaged evenness measure for each species is then corrected by the factor K_1 which results from the relationship between domestic and non-domestic production of forest reproductive material. In a next step these corrected measures are weighted by the factor K_2 (Norway spruce 0.5, other forest tree species 0.1) that accounts for different distribution areas. Please note that that less common species are over-weighted. Following example may further explain the calculation.

[77] Gregorius, H.R. (1984): A unique genetic distance. Biometrical Journal 26: 13-18.
[78] All oaks species are combined.

Example

Step 1

Establishment of the **specific reference quantity** for the tree species (in this example cone weight in silver fir) per seed stand. Determination by means of the lower quartile of the harvest quantity of the measurement period 2003 – 2011.

Result:
Reference quantity 300 kg (calculation based upon data not shown here.)
This reference quantity applies also to future measurement periods for silver fir.

Step 2

Determination of the evenness for individual years. As an example the year 2003 is shown here.

The annual yield quantity (3947 kg) is divided by the reference quantity and results in an approximated, theoretical number of seed stands.

Theoretical number of seed stands = 3947 kg/300 kg =13.16 = 14 (rounded up)

From which can be calculated the potential yield quantity per stand: 3947/14=281.9 kg

Calculation of the expected relative proportion p_e
p_e= 281.9 kg / 39847 kg = 0.07142857

Calculation of the actual relative proportion p_a of the yield quantity per stand
Seed stand 1 p_a = 132.50 kg / 39847 kg = 0.03356980
Seed stand 2 p_a = 163.00 kg / 39847 kg = 0.04129719
…
…

Step 3 **Determining the evenness E**

$E = 1 - ½\ \Sigma\ |\rho_e - \rho_a|$ (Gregorius 1984)

Next the percentile proportions of the expected value ρ_e (for even harvest of the theoretical number of seed stands) and actual value ρ_a are calculated.

Seed stands	Yield quantity	ρ_e	ρ_a	$\lvert\rho_e - \rho_a\rvert$
1	132.50	0.07142857	0.03356980	0.03785877
2	163.00	0.07142857	0.04129719	0.03013138
3	157.00	0.07142857	0.03977705	0.03165153
4	138.00	0.07142857	0.03496326	0.03646531
5	550.00	0.07142857	0.13934634	0.06791777
6	421.00	0.07142857	0.10666329	0.03523472
7	430.00	0.07142857	0.1089435	0.03751493
8	548.00	0.07142857	0.13883963	0.06741105
9	451.00	0.07142857	0.114264	0.04283543
10	300.00	0.07142857	0.07600709	0.00457852
11	310.00	0.07142857	0.07854066	0.00711209
12	346.50	0.07142857	0.08778819	0.01635962
13	0.0	0.07142857	0.0	0.07142857
14	0.0	0.07142857	0.0	0.07142857
Total				**0.55792826**

$E = 1 - 0.5 \times 0.55792826$

$E = 0.72103587$

Step 4

Over the monitoring period the seed harvests vary. Therefore the yearly even distribution values are weighted with the respective yearly harvest quantities (here not shown).

Step 5

In order to account for movement from non EU-Member States and movement of forest reproductive material within the EU a correction factor *K* for the species specific evenness is determined.

$$K_1 = \frac{\text{Seed quantity (netto)}}{\text{Seed quantity (netto) + Movement within EU}}$$

Seed quantity =
Domestic seed production minus seed exports of Austrian origin

Imports[79] = Seed and plant imports[80] of non-Austrian origin

The evenness is multiplied by this correction factor *K*

Step 6

The corrected evenness for the six tree species are weighted with an expertly determined factor and result in the biodiversity points.

[79] Imports refer here to shipments from EU-countries and the imports from non-EU countries.
[80] Plant imports are converted to their equivalent in seed imports.