GUIDELINE FOR ECOSYSTEM-BASED FOREST MANAGEMENT IN LANDSCAPE CONSERVATION BUFFER SUBZONES OF WORLD HERITAGE BEECH FORESTS

D.T2.3.3

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Description of the Deliverable

The Deliverable D.T2.3.3 consists of the creation of the Guideline on Ecosystem-based Forest Management. It is developed mainly from the work on WP T2, but also taking into consideration results from WP T1 and WP T3.

Two very important activities were the Workshop on Sustainable Forest Management Practices to Jointly Develop Common Guidelines (D.T2.3.2) and Discussions with Stakeholders and Interested Public (D.C.2.4), which was organised together with an additional seminar regarding the draft version of Handbook. Within this additional seminar, the developers of this Deliverable discussed the draft version and ideas with other project partners and forestry experts. Deliverable D.T2.3.1 also served as an important basis for these activities.

In this Handbook we used many ideas, knowledge and best practice examples which were presented in the Workshop (D.T2.3.2).

In parallel to this Handbook, the Handbook of Beech Forest Quality Standard and Certification System – "Code of Quality Management for WH Beech Forests" (D.T3.3.3) is also being developed by WP T3 responsible partner, Eberswalde University for Sustainable Development. Since both handbooks will present some criteria and indicators, we will try to connect these two documents with each other and present at least some indicators, principles or criteria that would be included in both documents.

The Guideline on Ecosystem-based Forest Management (D.T2.3.3) is the middle step to the Output O.T2.5 – Strategies for Sustainable Forestry Practices in Buffer Zones of WH Beech Forests PAs. All other related project activities are presented in the table below.

Table 1: BEECH POWER project deliverables and outputs related to the present deliverable.

Type of project result	Code	Title
Deliverable	D.T1.1.2	Participatory situation analyses (Germany, Slovenia, Croatia)
Deliverable	D.T1.2.1	Participatory strategy development (Germany, Slovenia, Croatia)
Deliverable	D.T2.1.2	Guidelines for stakeholder involvement and a related communication strategy
Deliverable	D.T2.1.3	Strategy for conflict management
Deliverable	D.T2.3.1	Joint assessment of current forest management situation
Deliverable	D.T2.3.2	Workshop on sustainable forest management practices
Deliverable	D.T2.3.5	Coordination meeting for preparation of workshop D.T2.3.2
Deliverable	D.T3.3.1	WS structure and set of criteria and indicators
Deliverable	D.T3.3.2	WS Certification System Agenda
Deliverable	D.T3.3.3	Handbook of Beech Forest Quality Standard and Certification System
Deliverable	D.C.2.4	Discussions with stakeholders and interested public
Output	O.T1.2	Strategy for the creation of additional participatory processes in the surroundings of PAs
Output	O.T1.3	Testing of pilot model for local WH working groups
Output	O.T2.1	Strategy for the active involvement of stakeholders in WH beech forests
Output	O.T2.2	Strategy for conflict management in buffer zones of WH beech forests

Acronyms

BEECH POWER – Interreg Central Europe project: World Heritage BEECH forests: emPOWERing and catalysing an ecosystem-based sustainable development

dbh – Diameter at breast height

ES – Ecosystem Services

FAO – Food and Agriculture Organisation of the United Nations

FMP – Forest Management Plan

FMU – Forest Management Unit

IRSNC - Institute of the Republic of Slovenia for Nature Conservation

IUCN – International Union for Conservation of Nature

JMC – Joint Management Committee

NPG – Nature Protection Guidelines

OUV – Outstanding Universal Value

SFM - Sustainable Forest Management

UNESCO – United Nations Educational, Scientific and Cultural Organization

WH - World Heritage

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Glossary of forest management terms

The terms listed below are taken from “Glossary of Forest Management Terms”, published in **Guidance Document on Buffer Zone Management and Buffer Zonation**, published on April 13, 2021 by the Joint Management Committee (JMC). The purpose of this is to create a common language and joint understanding of the WH property and its buffer zones. In this guideline we tried to follow the terminology, which was agreed within the JMC and States Parties that are included in this transboundary nomination of Ancient and Primeval Beech Forests of the Carpathians and Other Regions of Europe.

Preparation of the Guidance document by JMC was a long process where many compromises were taken between all States Parties in order to agree on the terminology. We at Slovenia Forest Service are of the opinion that this step was very important for future unification of terminology. At the same time, we need to point out there are still many differences where not all State Parties agree on specifics and are not completely satisfied with the final outcome. Therefore, we suggest that this Glossary should not be a closed chapter and should be still reviewed and evolved when the initiative is given. In this sense, we add the term forest ecosystem to the list.

Table 2: An overview of forest management terms, defined in the “Glossary of Forest Management Terms” for common transnational use in the WH property.

A silvicultural system	<u>A planned series of treatments for tending, harvesting, and re-establishing a stand. The silvicultural system is applied in the forest stand or forest management unit.</u> The forest stand is a homogeneous unit within the forest that has a certain structure and tree species composition and is managed in the same way, areas can differ from very small (< 1 ha) to very large (up to 50 ha).
Even-aged silvicultural system	<u>A planned sequence of treatments designed to create or maintain a stand with predominantly one age class.</u> The range of tree ages for an even aged forest is generally assumed to be 20 % or less of the rotation age.
Uneven-aged silvicultural system	<u>A planned sequence of treatments designed to create or maintain a stand with three or more age classes.</u> These silvicultural systems include cutting methods designed to obtain regeneration (regeneration cutting methods), and a variety of cultural practices for modifying tree density and otherwise contributing to the development of an immature stand (intermediate cutting methods), which is especially the result of single tree or group selection systems. In the single tree selection (plentering) (natural) regeneration is not an aim but has to be considered because of harvesting a single mature tree.

Non-intervention forest	**<u>Characterized by the lack in formal management, e.g. in the preference of natural development of forests for nature conservation purposes.</u>** As the lack of formal management measures is a consequence of a management vision it should be viewed as a management regime. In some forests a non-intervention regime is the only management measure applied. Areas in the forest with explicit and deliberate choice of non-intervention can be larger (10-1000 ha, often defined as 'forest reserve') or smaller areas (0,5-10 ha), embedded in a matrix of managed forests (often called 'set-aside patches').
Even-aged Management	**<u>This involves application of regeneration and intermediate cutting methods to create and maintain an even-aged stand.</u>** The even-aged regeneration cutting methods are clearcutting, seed-tree cutting, and shelterwood cutting. The even-aged silvicultural system also includes thinning, improvement cutting, release, and other intermediate cutting methods.
Clearcutting system	**<u>The harvesting in one operation of (almost) all trees with the expectation that a new, even-aged stand will be established.</u>** In the context of this document, we define a minimum surface of 0,5 ha. Intervention areas smaller than that are covered as 'group fellings' or 'femel cutting'. (The size limit of the intervention area is related to the circular area with a diameter between 2 and 3 times the tree height of mature trees). There are many variants of clearcutting (a common variant is strip clearcutting): nevertheless, independent of form the same rule on the intervention area can be applied. In modern clear-cut areas, some trees may be spared from felling (tree retention, e.g. habitat trees). The remaining canopy cover after clearcutting is below 30 % of the initial cover.
Shelterwood cutting system	**<u>This regeneration method involves a series of entries designed to improve the vigour and seed production potential of residual trees, and to provide suitable conditions for seedling establishment.</u>** To be considered the shelterwood method, the prescription must include an explicit regeneration objective. Generally, the shelterwood cutting method is used to create an even aged or two-aged stand, the regeneration period is about 20 to 30 years. Theoretically a shelterwood cutting could involve from two to four steps. A four-step shelterwood includes a preparatory cut, a seed cut, first removal and final removal cut. A two-step shelterwood includes a seed cut and a removal or final cut. We distinguish a uniform shelterwood and a group shelterwood. Uniform shelterwood means that the seed cut and removal cut are applied to the entire stand area. In a group shelterwood system, cuttings are limited to smaller plots. In the context of this WHS we refer to a group shelterwood system whenever the plots or groups are smaller than 0,5 ha. Regulations for group shelterwood systems are mentioned together with femel cutting.

Uneven-aged Management	Uneven-aged management uses regeneration and intermediate cutting methods to create and maintain an uneven-aged stand. The uneven-aged regeneration methods are individual tree and group selection cutting. Regeneration period is continuous.
Individual tree selection or plenter cutting	This silvicultural system involves removing selected trees from specific size or age classes over an entire stand area. Removing single trees creates small openings so this method favours the regeneration of species that can tolerate shade. Individual tree selection is used to create or maintain an uneven-aged stand, reflecting a predefined (semi-)natural age or size distribution. It involves periodic selective harvests (final harvest and thinning combined), and no rotation period and continuous regeneration.
Group selection or femel cutting	This silvicultural method involves final felling of small groups of trees. The resulting openings permit more sunlight to reach the forest floor than with individual tree selection, and some regeneration of shade intolerant species is possible. Planned repeated application of group final fellings result in small groups or clumps dispersed through a stand, with each group containing trees of similar age and size classes. We refer to group selection whenever the intervention area is smaller than 0,5 ha.
Non-native tree species	A tree species living outside its historical or actual native distributional range, but which has arrived there by human activity, directly or indirectly, and either deliberately or accidentally.
Tending operations in young stands	In even-aged stands, between the period when a tree stand is established and the first commercial harvesting operation, there are a number of tasks that are carried out to allow access to the stand and improve survival rate, tree form, and wood quality of young trees. In Europe we normally distinguish tending and thinning: **Tending (pre-commercial thinning):** operations to improve the tree shape and spacing and tree species composition, but with no financial revenue, only investment in increased survival of trees (suppression of competing vegetation) and tree shape and quality. **Thinning**: selective removal of trees, if the felled trees can be sold we refer to commercial thinning
Cuttings due to extreme events or salvation harvests	Sanitary cutting - extraction of dead, damaged, broken and fallen trees etc. To improve the phytosanitary condition of the forest stand. It is applied in the situation where the stand is affected by biotic factors (pest attacks) and the extraction of the affected trees is not part of the regular management but is necessary in order to prevent further spread of a biotic disturbance agent (e.g. insect or fungal infection) to the remaining forest stand or adjacent unaffected forest stands = a specific situation of 'salvation harvest'.
Artificial regeneration	Active planting of trees, grown in nurseries. Often applied if the natural regeneration is not sufficient or does not include specific target tree species.

Natural regeneration	Regeneration from seed or vegetative parts originating from trees on site.
Assisted natural regeneration	Natural regeneration of forest/other wooded land with deliberate human intervention aimed at enhancing the ability of desired species to regenerate. Works to help natural regeneration establishment and growth (age of the trees: 0-5 years, approximately). E.g.: Scarification of the soil to create good germination conditions for seeds.
Functional network of old-growth elements	This contains: conservation and development of old-growth patches (set-aside and extended rotation patches), habitat trees (individual trees or clusters) and large dead wood.
Set-aside patches	Areas that are deliberately delineated to conserve or develop to old-growth stages through non-intervention.
Extended rotation patches or senescence patches	Areas that remain managed but are deliberately delineated to develop old stands by significantly extending the rotation period or excluding final harvest (only selective thinning).
Corridors	Connecting areas between the component parts of the functional network of old-growth elements and other biodiversity hotspots, containing a high concentration of old-growth features.
Habitat tree	Tree containing Tree Related Microhabitats (TReM's - Larrieu et al., 2018): they are preferably (or wherever possible) large and old trees (mature or over-mature).
Tree related Microhabitat (TreM)	A distinct, well delineated structure occurring on living or standing dead trees, that constitutes a particular and essential substrate or life site for species or species communities during at least a part of their life cycle to develop, feed, shelter, or breed. TreMs are specific aboveground tree morphological singularities that are not to be found on every tree. TreMs encompass both tree-originating modifications caused by biotic and abiotic impacts, such as intrusions, lesions, and breakages, which expose sap and heartwood and initialize outgrowth structures and wood decay (saproxylic TreM), as well as elements of external origin that are physically linked to the tree (epixylic TreM).
Protection buffer subzone	The subzone with a strict protection regime and located directly around the component part. The protective function of this subzone is closely related to the threats that have local origins and short distance effects. Generally a buffer zone with protective function has a minimum width of 100 m. Management is limited to very small-scaled interventions.

Landscape buffer subzone	**<u>The wider subzone addressed to protect the forest landscape of the surrounding area.</u>** This subzone serves as an important buffer of the meso-climatic situation and provides good connectivity between component parts included in the same buffer zone, as well as to the surrounding ecosystems.

Table 3: The below terms are defined solely in this document to avoid confusion between readers.

Extensive management	**<u>Management that focuses on obtaining timber from a large area with minimal interventions.</u>** Extensive management (e.g. close-to-nature forestry) focuses on spreading the production function of forests over a wider area to lessen its effect on other forest functions. Interventions are minimal, regeneration strives to be natural, logging is small-scale. This type of management requires adaptation, monitoring and a lot of planning.
Intensive management	**<u>Management that focuses on achieving maximum timber production in a limited area.</u>** Intensive management (e.g. clear-cutting) focuses on the production function of forests. The production function and use of heavy machinery is emphasised. Larger forest areas are cleared, but this neglects other forest functions. This type of management requires less planning and no adaptation to natural processes.
Forest ecosystem	A dynamic complex of plant, animal and microorganism communities and their abiotic environment interacting as a functional unit, where trees are a key component of the system. Humans, with their cultural, economic and environmental needs, are an integral part of many forest ecosystems (CBD, 2006).
Ecosystem functionality	The operational state of ecosystems, characterized by inherent structures, ecological processes and dynamics that provide ecosystems with both the necessary (energetic, material and hydric) efficiency and resilience to function effectively without (abrupt) alteration to system properties or geographical distribution during periods of external change. Ecosystems develop greater functional efficiency when they harbor more biomass, contain more information, and are organized more complexly with a high degree of connectedness among the system's elements (Ibisch&Hobson, 2014).

1. Summary

The purpose of the **Guideline on Ecosystem-based Forest Management in Landscape Conservation Buffer Subzones of World Heritage (WH) Beech Forests** is to support forest managers in applying present best practices of forest management.

Based on the principle of ecological functionality (according to the Code of Quality Management, D.T3.3.3) the Guideline presents criteria for ecosystem-based forest management, which can be incorporated in landscape conservation buffer subzones of UNESCO WH beech forests. Good practice examples are included in special grey text boxes.

The **Guidance document on buffer zone management and buffer zone zonation** differentiates between two possible buffer subzones: protection and landscape conservation buffer subzone. Since protection buffer subzones have mainly non-intervention regimes (except for interventions to preserve the OUV), this document is intended for the **landscape conservation buffer subzones**, where different activities and interventions are allowed. Detailed descriptions of buffer zones and subzones are included in chapter **2.1 Buffer zone**.

The main principles are sustainability, ecosystem approach, and close-to-nature forestry. Sustainability is vital to ensure the preservation of forests and their various ES, not just wood production. The ecosystem approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. It requires adaptive management to deal with the complex and dynamic nature of ecosystems. Close-to-nature forestry tries to mimic natural processes of forests to a full extent, in order to preserve ecological, production and social functions of forests.

Forests provide many important ecosystem services (ES) for humankind, including biodiversity, climate regulation, soil protection, water regulation and different cultural services. Therefore**, ecosystem-based forest management** is necessary to protect and ensure the functioning of all of these services.

A management plan is a necessary prerequisite for effective forest management. It should serve as the basis for all activities undertaken inside a forest area. Forest management of the landscape conservation buffer subzone should be adaptive and based on natural processes of forest ecosystems. Constant monitoring of forest conditions should provide data to guide decision-making.

The following criteria are defined as necessary for appropriate forest management in the landscape conservation buffer subzone:

- Maintenance of natural forest structure
- Promotion of natural regeneration
- Avoidance of non-native tree species
- Optimization of growing stock
- Maintenance of diverse forest edges
- Maintenance of farmland forest elements
- Conservation of biodiversity
- Protection of intangible benefits
- Species management
- Sustainable visitor management

Indicators with reference values are provided for each criterion. **Chapter 6** on best practice examples presents examples of respective management approaches, which can be taken into consideration.

2. Introduction

The objective of the **Guideline on Ecosystem-based Forest Management** is to support forest managers in applying appropriate forest management in landscape conservation buffer zones of WH beech forests and to present best practices of management. The Guideline presents criteria for ecosystem-based forest management, which can be incorporated in the target areas. A selection of good practice examples is presented in special grey text boxes in the document.

The overall goal is to encourage forest managers to apply management practices that target the maintenance of healthy and resilient forest ecosystems, regarding their buffer function – in particular regarding increasingly accelerating climate change and related negative impacts (on the component part) as well as regarding the provision of further ecosystem services.

This is why the main focus of this guideline is on incorporating the principle of **Ecological functionality** in forest management systems within the scope of the (landscape conservation) buffer zone (**BZ**), included in the Code of quality management for WH beech forests (Figure 1).

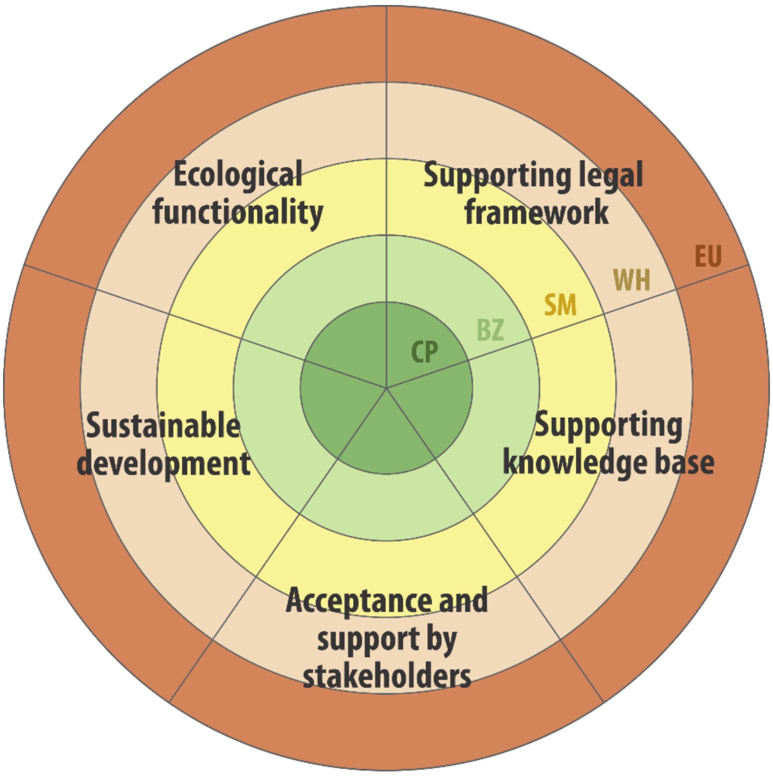

Figure 1: Five values for quality management, based on the Code of Quality Management, for five different spatial scales: **CP** (component part), **BZ** (buffer zone), **SM** (surrounding matrix), **WH** (World Heritage Site), **EU** (European beech forest ecosystem).

While component parts of WH beech forests should be left without management, buffer zones have a different purpose. Their purpose is to buffer the effects of anthropogenic activity, which can result in changes inside component parts. Since many component parts of the WH beech forest property have large buffer zones, their management is an important factor regarding the state of the forests inside the component parts. If we want to ensure component parts do not suffer any consequences of human activity in surrounding areas (buffer zones and the wider landscape), we have to adapt the forest management system in surrounding areas to a sustainable, ecosystem- and close-to-nature-based approach, in order to provide the best possible protection for forest ecosystem integrity and Outstanding Universal Value (OUV) in the component parts.

The Guideline has the aim of presenting and explaining the whole procedure, which will help different forest managers to manage their buffer zone forests in the most low-impact and economically sustainable way. Adopting these procedures and guidelines in forest management plans is a continuous and long-term process. In order to meet the proposed criteria, in many cases changes in national legislation are needed and new standards, protocols, and methods need to be developed and implemented. Not only laws, but in many cases, a change of behavioural patterns, philosophy and approach is needed on different management levels (from forest owners and forest managers to the national level) in order for new knowledge to be adopted by generations of foresters and people working with these ecosystems on different levels.

Depending on the country, area, or forest, it can take anything from a few years to a few decades in order for ecosystem-based forest management system to be recognised in the forest – i.e. for the state of naturalness of the forest area to improve sufficiently and for the ecological processes to follow the required indicators.

It is important to emphasise that this Guideline can present only an orientation, regarding the desired state of different criteria. Each forest manager knows the limitation of their forest and area and should adapt the management plan accordingly. For example, wood stock in lowland beech forests can reach over 400 m^3/ha, while in alpine and subalpine beech forests it can barely reach 300 m^3/ha. On even more extreme locations the wood stock can reach just over 100 m^3/ha (trees do not even reach 40 cm dbh) (SFS, 2015). Wood stock is maybe one of the most distinct cases for differences in beech forests, due to geographical and climate conditions. We need to take these factors into account and set our goals in relation to the potential of the forest.

Many European countries, which are included in the WH site of **Ancient and Primeval Beech Forests of the Carpathians and Other Regions of Europe** have different sustainable forest management practices already included in their management plans. Here we need to emphasise that this sustainability is presented mainly in terms of forest cover (net zero decrease of areas covered with forest) and economic sustainability. But SFM should be much more than only taking care of the forest cover, wood stock and economic profit; the emphasis should be on the **sustainability of forest ecosystem functionality**.

With the Guideline we will try to present how we can efficiently ensure sustainability of all forest functions with use of close-to-nature forest management and multipurpose forest management approaches, which are also identified in the New EU Forest Strategy for 2030 (European Commission, 2021a) as contributors to achieving the EU's biodiversity objectives as well as its greenhouse gas emission reduction target of at least 55 % by 2030 and climate neutrality by 2050 (European Commission, 2021b). The New EU Forest Strategy for 2030 recognises the central and multifunctional role of forests, and the contribution of foresters and the entire forest-based value chain to achieving a sustainable and climate neutral economy by 2050 and preserving lively and prosperous rural areas (European Commission, 2021a). To prevent confusion with existing SFM definitions and practices in different countries, this handbook uses the term **ecosystem-based forest management**.

2.1. Buffer zone

The buffer zone is intended to protect the OUV of the property and is not part of the property and neither a contribution to the integrity of the property or to the OUV. According to IUCN (Martin and Piatti, 2009) an effective buffer zone aims to perform the following functions:

1. The effective management of a buffer zone aims to maximize the protection of the values of the protected area (including the Outstanding Universal Value of a WH property) and their resilience to change.
2. To maximize the connectivity of the WH property with other natural lands in a landscape as a basis for responding to climate change caused biome shifts of fauna, flora and habitats – and to maximize landscape connectivity; habitat connectivity, ecological connectivity, and evolutionary process connectivity (Worboys et al., 2010).
3. To integrate the WH property within landscape scale conservation with community initiatives for sustainable use practices including catchment protection, the conservation of healthy environments and the realization of sustainable livelihoods.

To guarantee functionality of the buffer zone, the entire buffer zone has to be located on land that is under direct or indirect control of the management authority in charge of the component part or under direct control of the States Party (e.g. state-owned forest areas). In case a strictly protected forest reserve borders directly on a private forest without legal regulation, the buffer zone needs to be located inside the strict reserve to guarantee full control of buffer zone management. In order to avoid a reduction of the size of the component part, the better option is to find a long lasting and binding agreement on adequate management with the owner of neighbouring forest stands (JMC, 2021).

In order for the buffer zone to provide different functions, different management approaches might be needed. To avoid confusion and to be clear which management regulation has to be applied to which part of the buffer zone, it might be necessary to spatially separate two different subzones inside one buffer zone with regard to these management approaches (JMC, 2021):

1. Part of the buffer zone with protective function from short distance threats (**protection buffer subzone** or p-buffer)
2. Part of the buffer zone with landscape conservation and connectivity function (**landscape conservation buffer subzone** or l-buffer)

2.1.1. Protection buffer subzone

This is the subzone with a strict protection regime and located directly around the component part. The protective function of this subzone is closely related to the threats that have local origins and short distance effects. If the component parts are located close to agricultural land, a buffer zone can protect them from the impact of pesticides or fertilisers. In cases where the property is bordering on economically managed forests, the most likely negative impacts on the property are caused by forestry, leading to a significant reduction of the canopy of adjacent forest stands (JMC, 2021).

Management is limited to very small-scaled interventions. Single trees might be removed for phytosanitary purposes to protect the property from invasions of foreign pests. Security cuts along established trails are permitted to maintain safety for visitors. Hunting for game management is allowed. Active management of invasive species is also permitted. All these interventions are allowed for the purpose of preserving the component part and its OUV. Special concessions are also allowed for hiking trails, if redesigning them leads to improved integrity of the site. Natural hazard prevention is possible with special permission as long as natural processes are not disturbed.

A protection buffer subzone is obligatory for each component part and is considered as the whole buffer if no sub-zoning takes place. Generally, a buffer zone with a protective function has a minimum width of 100 m (JMC, 2021).

2.1.2. Landscape conservation buffer subzone

The landscape conservation buffer subzone is addressed to protect the forest landscape of the surrounding area, as an important buffer of the meso-climatic situation and to provide good connectivity between component parts included in the same buffer zone, as well as to the surrounding ecosystems. It is not obligatory for a component part to have a landscape conservation buffer subzone. The landscape subzone surrounds the protection subzone and is generally much larger.

To enhance its buffer function, it is important to protect the adjacent landscapes from negative developments (Figure 2). Landscape conservation buffer subzone can connect more than one component parts. Therefore, its connecting function is of high importance. Whenever a landscape conservation buffer subzone is relevant, the connective functions require specific management regulations in order to establish a consistent and functional ecological network.

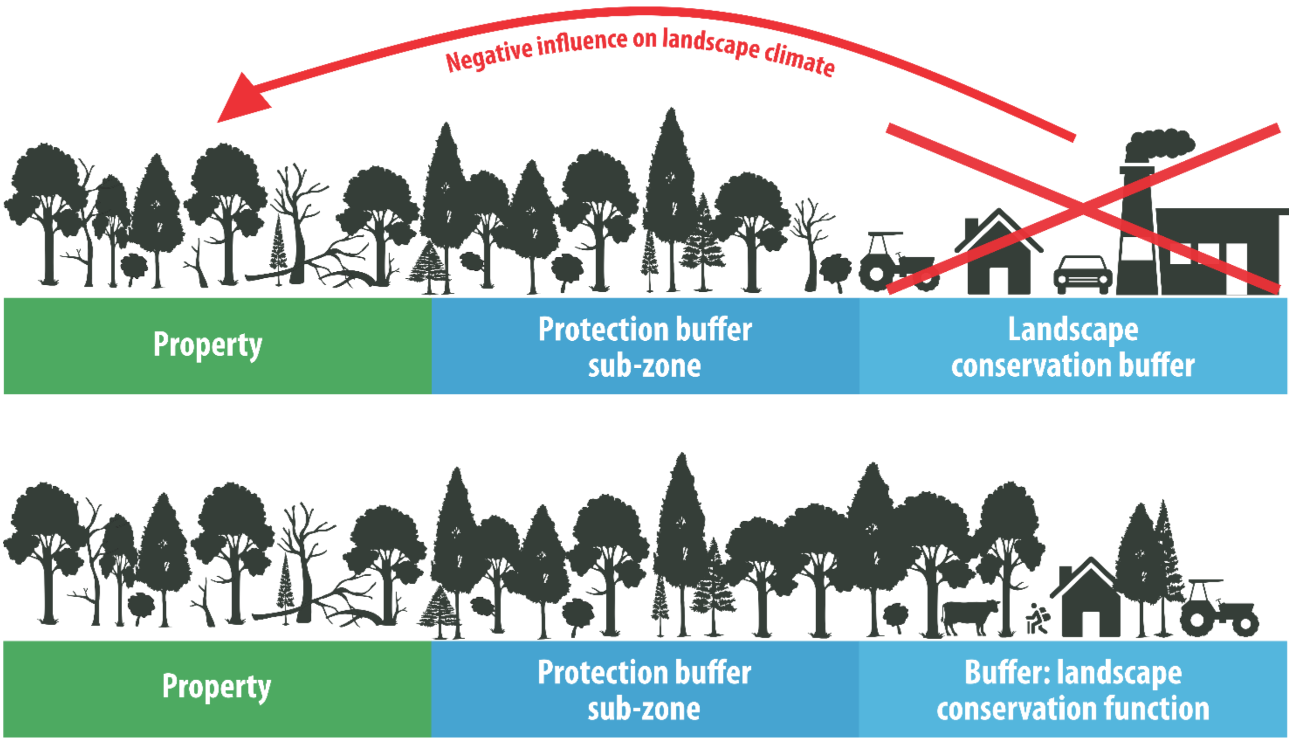

Figure 2: The Landscape conservation buffer subzone should protect the wider landscape from negative developments (adapted after JMC, 2021).

The separation between protection and landscape conservation buffer subzones is needed in locations where buffer zones are very large and where different human activities are positioned inside them. It is important to understand that there is only one buffer zone according to the UNESCO Operational Guidelines. The sub-zoning is only necessary for buffer zones where different management regimes are applied. A buffer zone of sufficient size and regulation adequate for a protection buffer subzone does not need to establish an additional landscape conservation buffer subzone (JMC, 2021). Protection buffer subzones have **mainly non-intervention** regimes. The only interventions possible there are on a very small scale.

Therefore, the management guidelines described in this document are relevant only for landscape conservation buffer subzones, where interventions and active management are performed to maintain the subzone's functions.

2.2. Forest ecosystem management in the climate crisis

Forests, woodlands, and woody debris, especially when they are fragmented by land use and infrastructure, are exposed to multiple unfavourable edge effects, and are further increasingly exposed to climate change impacts (Ibisch et al. 2021a). Here, in particular extreme events, e.g. heat waves, drought periods, combined with changed temporal distribution of precipitation.

The importance of climate changes was also stated in the third IUCN World Heritage Outlook, which was issued on 2nd of December 2020. It shows that climate change is now the top threat to natural World Heritage sites (Osipova et al., 2020).

The example from Germany shows that Summers 2018-2020 were the most extreme in Germany to date: they were among the warmest since the beginning of weather records and were drier than average. Some regions not only experienced prolonged drought, but also exceptionally high maximum temperatures, which resulted in a decreasing vitality of forest ecosystems and to dieback on tree and stand level (Ibisch et al. 2021b),

There are clear indications that damaged deciduous forests are mainly those that had to cope with the heat and drought events after more intensive use and corresponding thinning. Using the example of the UNESCO World Heritage Site "Ancient and Primeval Beech Forests of the Carpathians and Other Regions of Europe" (component parts: Kellerwald National Park, Hainich National Park, Grumsin in the Biosphere Reserve Schorfheide-Chorin, Serrahn in the Müritz National Park, and Jasmund National Park), it is shown that some of the mixed deciduous forests, which are less managed or not managed at all by forestry, came through the extreme years. (Ibisch et al. 2021b)

Forest harvesting can cause significant forest warming by thinning the canopy and removing biomass – especially on hot days. Extreme heat damages forests in several ways, e.g. through direct damage to plant tissues ('burning' on bark and leaves of trees), drying effect of warm air and increased evaporation leading to further water stress.

The reduction of areas covered with vital forest can have a significant ecological impacts. These include, above all, consequences for the landscape water balance. This causes the risk of an increase in water losses and possibly even a decrease in water supply. In addition, a uniformly positive evapotranspiration contribution from forests suggests that they play a key role in maintaining precipitation during critical heat wave periods. Accordingly, there is a threat of significant positive feedbacks, i.e., a reinforcing negative spiral: Drought-stress-induced tree loss leads to warming and desiccation, which can result in the reduction of precipitation and thus the increase of drought stress.

Such climate conditions currently perceived as "extreme" (Büntgen et al., 2021) could be be considered "normal" in the near future (Hari et al., 2020; Scharnweber et al., 2020). It is therefore of great interest to what extent forestry management (especially thinning) has the potential to reduce the negative effects of heat waves in forest stands.

The microclimatic regulation capacity of forests is therefore of central importance. The main issues are the mitigation of peak summer temperatures, the lowering of average temperatures and the lowering of average temperatures and buffering of temperature fluctuations.

The biomass stock also influences the temperature regime. This means that the more densely a forest stand is stocked the lower is it's the maximum temperature.

A closed forest has a better cooling capacity (preventing relatively high temperatures) and greater buffering capacity.

For the mitigation of maximum temperatures in the forest interior, the openness of the canopy is the critical factor, but the amount of trees felled is also of great importance, and both variables are directly controlled by forest management (in terms of reducing timber harvesting activities and the development of denser, multi-layered forest stands).

For any forest management activity in landscape conservation buffer zones of WH component parts it needs to be considered to minimize warming and evaporation effects in the forest interior by minimizing the creation of artificial gaps in the canopy through forestry measures. This includes intensive thinning and clear-cutting, as well as the establishment of roads and skid trails, which should be reduced or avoided. In this context, fragmentation of forests by roads and infrastructure, as well as opening of the canopy through the construction or maintenance of forest roads must be critically discussed.

3. Concepts and approaches to consider for ecosystem-based forest management

3.1. Multi-functionality of forests

Forests provide a plethora of functions, important for human well-being. The approach of forests' multi-functionality aims to evaluate all the functions forests provide us. One vital factor in the principle of multi-functionality is that all the described forest functions are **equal to one another**. Therefore, forest management must take into account all the various functions when preparing management actions, because performing one function should not threaten forests' ability to perform other functions as well.

Forest functions can be defined by legislation as such (Act on Forests, 2016) and should be prioritized in landscape conservation buffer zones of WH component parts in the following order:

- **ecological functions** (protecting forest stands, preserving biodiversity, hydrological function, climatic function)
- **social functions** (protecting infrastructure, recreation, tourism, education, research, health function, protecting natural and cultural heritage, defensive function, aesthetic function)
- **production function** (wood and timber production, hunting, production of other forest goods)

3.2. Ecosystem approach

The ecosystem approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. It is based on the application of appropriate scientific methodologies focused on levels of biological organization, which encompass the essential processes, functions and interactions among organisms and their environment (CBD, 2021).

It requires adaptive management to deal with the extremely complex and dynamic nature of ecosystems. Despite constant data gathering and research, management always makes decisions with the absence of complete knowledge or understanding of ecosystems' functioning. Ecosystem processes are often non-linear, and the outcome of such processes often shows time-lags. The result is discontinuities, leading to surprise and uncertainty. Management must therefore be adaptive to be able to respond to such uncertainties. Management must contain elements of "learning-by-doing" or research feedback. Measures may need to be taken even when some cause-and-effect relationships are not yet fully established scientifically (SCBD, 2004).

The comparative analysis of SFM and the ecosystem approach made by FAO (Food and Agriculture Organisation) found out that the concepts were very similar and should be integrated and mutually supportive at all levels (SFS, 2008).

3.3. Sustainable Forest Management

The concept of sustainability in forestry was developed from the concept of sustained yield, which refers only to the forest's productive function. In its broadest sense, SFM encompasses the administrative, legal, technical, economic, social and environmental aspects of the conservation and use of forests (FAO, 2021). SFM should not only focus on maintaining a constant amount of wood stock (e.g., by replanting or allowing natural regeneration). Such an approach, focused mainly on wood production, neglects a variety of different forest functions and leaves room for mismanagement, such as clearcutting (Čater and Diaci, 2020a; Blumröder et al., 2020; FSC, 2022). Different countries also have different definitions and criteria for SFM (Holvoet and Muys, 2004). As such, this term is not used in this guideline, we instead use the term **ecosystem-based forest management**.

3.4. Close-to-nature Forest Management

In Slovenia, the "classic sustainable forest management system" is not enough to address all aspects of forest functions. If we want each forest area to have suitable ecological, production and social functions, we have to go **even further from the usual sustainable forest management system** into a close-to-nature management system where we try to mimic natural processes of forests in full extent (see chapter **6.3 Slovenian Forestry School**).

Close-to-nature forestry is based on forest management plans adapted to individual site and stand conditions as well as forest functions (integration of different aspects, e.g. biodiversity conservation, protection of natural values), and considering natural processes and structures specific to natural forest ecosystems. Forest structure is adapted to site conditions and its climate. Natural processes are altered as little as possible and mimicked as much as possible, while still maintaining the financial profitability and social sustainability of forest management. Similar to natural processes, close-to-nature forestry also contains inbuilt mechanisms for continual internal checks (so-called control method, see **Box A1**) providing an adaptive management approach to modify measures in accordance with developmental characteristics of single forest stands and forest as a whole. Close-to-nature forest management uses natural regeneration and mimics natural disturbances and processes. In this sense, it combines the principles of sustainable forest management and the ecosystem approach (Čater and Diaci, 2020b).

The extraction of wood and other forest goods and the use of forests must be in accordance with the potentials and capacities of forests, which are determined by the natural development of forest communities. Forest management measures are adapted to forest dynamics, which ensures the preservation of the natural composition of forest habitats and their biodiversity, and strengthens the comprehensive resilience of forests and their ability to realize the productive, ecological and social functions of forests.

Replacing intensive forest management by close-to-nature, extensive forest management (e.g. selective logging) is also in line with the principle of ecological functionality (see chapter **4.1 Ecological functionality**). There is a variety of different extensive forestry techniques, with the main purpose of **maintaining uneven-aged stands** and **mimicking natural processes**.

Close-to-nature forest management is one of the few activities that organically connects economic activity with nature conservation. Such forest management is professionally demanding, so all measures in forests must be carefully planned. With the spatial planning system, which determines the intended use of land, forests are included in spatial plans at the national and local level. Management of stable and healthy forests, is less expensive than cultivation of artificial stands which can be quite productive on a short-term basis, but are hard to preserve in the long term, due to their higher vulnerability in comparison with natural forests (SFS, 2008).

3.5. Forest ecosystem services

Ecosystem services (ES) are all ecological processes in ecosystems or the products resulting from them that are used by people or that sustain and promote their lives or well-being (Ibisch et al. 2021).. They are divided into three groups: provisioning, regulation and maintenance, and cultural (Hassan et al., 2005). These services cover biotic as well as abiotic ecosystem outputs. In the following chapter we focus on the most relevant services only.

Forests provide many different ES (Figure 3) and provide some of the most critical ES to humanity (FAO, 2010). Forests play a multifunctional role in the balance of human commodity needs with the production of other services and goods, including the habitat needs of forest dependent organisms (Lindenmayer and Franklin, 2002; Thompson et al., 2011).

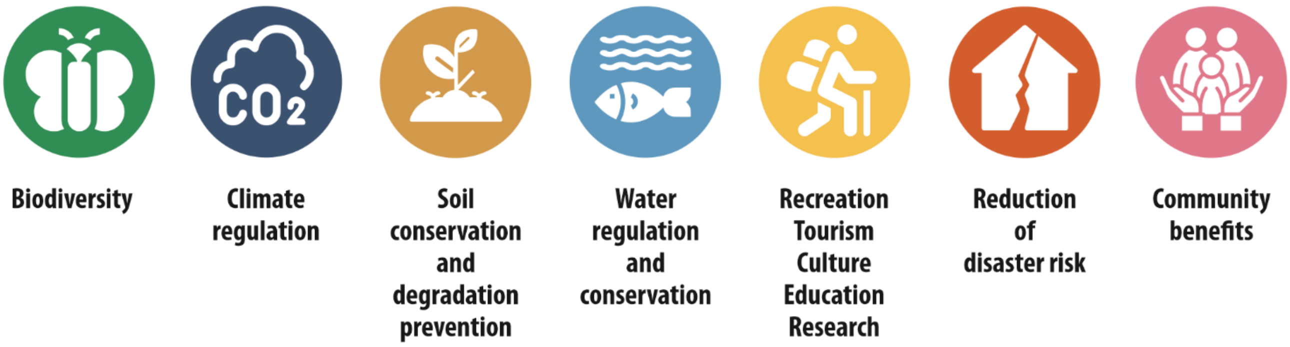

Figure 3: Forests provide a variety of important ecosystem services.

3.5.1. Biodiversity

Forest biodiversity is the result of evolutionary processes in the past millions of years that are driven by ecological forces such as climate, competition and disturbance. It refers to all life forms found within forested areas, not only trees, but all manner of flora, fauna, fungi and microorganisms that inhabit forest areas and their associated genetic diversity and habitat needs (CBD, 2016; Thompson et al., 2011). Forests are home to over 80 % of the world's terrestrial species of animals, plants and insects (United Nations, 2021). Forest biodiversity is interlinked in a network of other socio-economic factors, and provides a variety of goods and services that range from timber and non-timber forest resources to mitigating climate change. Forest biodiversity is innately linked to ecosystem and human well-being (CBD, 2010). Loss of biodiversity can have catastrophic impacts on ecosystem stability and their services.

3.5.2. Regulation of climate

Forests play a key role in the global carbon cycle with the removal of carbon dioxide (CO_2) from the atmosphere and its absorption and conversion into wood. CO_2 is released back in the atmosphere when trees are burned or decay. Forests are storages for CO_2 for only a partial amount of time and they can be marked as a source or sink of carbon, which can have an impact on the reduction of net amount of CO_2 in the atmosphere (Jenkins and Schaap, 2018).

Forest ecosystem also have huge impacts on buffering and mitigation of other climate elements (Brack, 2019).

These include:

- Temperature (cooling the atmosphere, reducing temperature levels),
- Winds (reducing strong winds and damage),
- Water (preventing evaporation, increasing water retention),
- Precipitation (amount, distribution, form)

3.5.3. Soil conservation and prevention of land degradation

Forest ecosystems play a crucial role in building and maintaining soil fertility all over the world. Roots of trees draw nutrients from the soil, which allows trees to grow and develop. When a tree decays it returns nutrients back to the soil and fertilises it. Complex networks of tree roots prevent soil erosion even on steep hillsides (Jenkins and Schaap, 2018). If trees are cut and forests cleared, the land is exposed to soil degradation and erosion. This can, in a worst-case scenario, lead to desertification and land's inability to support agriculture and forestry.

3.5.4. Water regulation and conservation

Forests are also an important water storage facility. Besides water storage, forests have important filtration, regulation, recharging and absorbing functions. Forest landscapes can therefore provide water for consumptive and non-consumptive human use, for aquatic productivity, flow regulation, storm/flood buffering and filtration of nutrients and contaminants (Jenkins and Schaap, 2018).

These watershed services, provided by forests, are very important in the provisioning of sufficient worldwide freshwater supply. Around one-third of the world's largest cities already obtain a significant amount of their drinking water directly from forested protected areas. If we include water sources originating in distant protected forested watersheds, this number increases to around 44 % of the world's largest cities (Stolton and Dudley, 2007).

3.5.5. Recreation, tourism, culture, education and research

Forest ES (e.g. biodiversity, climate regulation) are very important for society from a recreational, aesthetical, spiritual and cultural aspect. Forest areas often offer visitors many different recreational activities and options. Tourists and stakeholders who work in tourism also find these areas very important for their activities. We must also not forget culture, which was developed in forest areas and is still present there.

Forests themselves are also great classrooms in nature where visitors can learn about nature and its processes. This can be supported with different educational infrastructure (e.g. nature educational trails) where specific phenomena are presented and can be interpreted by visitors in a manner they understand best. Forests also offer a vast variety of options for research of their processes, flora, fauna etc. by different scientists.

3.5.6. Role of forests in reduction of disaster risk

Forests also play a crucial role in the reduction of disaster disk, since they act as a natural buffer. Forests can buffer direct and indirect anthropogenic effects that arise from cause-and-effect relation events. They reduce the possibility of extreme events/hazards in their frequency and severity. Forests mitigate flooding risk (Brack, 2019), prevent severe landslides, protect against avalanches, and maintain slope stability. They can also mitigate effects of drought (Dudley et al., 2015).

3.5.7. Community benefits

As seen from the above examples, forests provide many very valuable ES to the whole of humankind. While some forest ES have value only for specific stakeholders (e.g. tourists, hikers), some ES are valuable and irreplaceable to all (e.g. biodiversity, water regulation, CO_2 storage), and play a vital role in improving lives of communities worldwide

Understanding the natural processes and development of the forest ecosystem and applying its laws in management is the basis for the preservation of forests and their successful development in the future, when pressures on them will only increase. It is apparent we must manage forests sustainably with regard for all their ecosystem functions, not just wood production.

4. Principles of Forest Management in WH buffer zones

Sustainable forest management, as a dynamic and evolving concept, is intended to maintain and enhance the economic, social and environmental values of all types of forests, for the benefit of present and future generations (FAO, 2021). It means the stewardship and use of forests in a way that maintains their biodiversity, productivity, regeneration capacity, 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 (European Commission, 2021a). However, as different European countries use their own definitions and interpretations of SFM (e.g. some including clearcutting), we use a different term for this guideline. We use the term **ecosystem-based forest management,** as it is based on the ecosystem approach and adapting best practices from a variety of different management concepts and approaches (chapter 3). In the context of WH beech forests any management further needs to consider the principles of the Code of Quality Management that are relevant for the specific field of management – in this case, forest management in the landscape conservation buffer subzone of WH component parts.

In this regard ecosystem-based forest management is vital to ensure the preservation of forests and their various ES for the wellbeing of future generations. It combines the knowledge and experiences from forestry, ecology, and nature conservation. It can be measured by different criteria, which define the state of the forest area and processes that are evolving within.

The different component parts of the WH site present a heterogeneous collection of beech forests within individual landscape contexts, which means that each criterion and its indicator value cannot be carved in stone, but can (and has to) slightly vary between different forest areas. Because nature has shaped these areas and natural processes still prevail, we need to follow and mimic nature in the process of forest management and adapt our decisions based on site conditions and natural references we can find there.

4.1. Ecological functionality

Forest management in the landscape conservation buffer zone prioritises the ecological functionality of the component part and the embedding ecosystems. There are no negative impacts from forest management on the protection buffer zone or the component part. Forest management contributes to **maintaining ecological connectivity** of the component part to other forest areas.

4.2. Supporting regulatory and institutional framework

Forest management in landscape conservation buffer zones is based on an adequate legal, regulatory and institutional framework (legal, structural, financial and institutional).

A management plan is a necessary prerequisite for effective forest management. It should serve as the basis for all activities undertaken inside a forest area.

With regards to this, management plans should define the landscape conservation buffer subzone's current situation, its economic and conservation values, and opportunities and disadvantages regarding those values. They should define a timeline for plans and management actions in the economic and conservation sectors for a specified time period (usually 5-10 years). Management of the landscape conservation buffer subzone must be based on natural processes of forest ecosystems (close-to-nature forestry). Plans must take into account data gathered from monitoring and research. The management plan for the landscape conservation buffer subzone can be part of a wider management plan or a specific document focusing only on the landscape conservation buffer subzone. Management plan's goal should be to safeguard the functions of the landscape conservation buffer subzone and optimise its effectiveness in safeguarding the component parts' OUV.

4.3. Supporting knowledge base

Forest management in the landscape conservation buffer zone contributes to the generation, maintenance and development of a supporting knowledge base. It further has (access to) sufficient knowledge, expertise and skills to make profound management decisions. In this regard, different sources and formats of knowledge are used to support management decisions.

Research and monitoring is a vital part of forest management, as gathered data guides decision-making. Research of natural processes in a forest ecosystem gives insight into how forests function, which can influence management. Monitoring of forest development gives valuable data on which management actions are planned. The status of criteria can only be determined by regular and long-term monitoring. Monitoring can be undertaken differently depending on area conditions, pre-existing plans, national legislation and other variables. Two best practice examples are presented in **Box A1** and **A2**, respectively.

Alongside monitoring of forest dynamics, monitoring of protected, endangered and indicator species is also important to ascertain whether certain criteria of ecosystem-based forest management are met (e.g. amount of deadwood and habitat connectivity). Monitoring of endangered, protected or indicator species should be made according to species specific monitoring methodology. A database of all such species should be created as a reference for management actions. Ecologically important areas should be identified, mapped, and protected.

Research from different academic institutions that takes place inside component parts or buffer zones should be gathered and acknowledged. Research from external institutions has to be approved by the managing authority. Knowledge gained from research and monitoring activities should be included in management plans and guide decision making.

All the data that is already available, should be gathered in a common database. This can include a database of flora and fauna in the area, especially protected or endangered species. Based on monitoring of forest dynamics, a database of all gathered data should also exist. Existing and planned conservation interventions, such as established forest reserves, set-aside patches and habitat trees, should also be mapped and collated.

Ideally, the monitoring in the buffer zone should be part of a wider monitoring system. For the best possible protection of OUV and ecosystem integrity of UNESCO WH beech forests, it should be further developed into a wider monitoring system for the whole WH site.

The monitoring approach for component parts has already been harmonized between the five German component parts and the properties in Slovakia and Ukraine (Kirchmeir and Kovarovics, 2016). This should be expanded to include all the properties, and monitoring inside the buffer zones.

The online knowledge exchange platform provides a first attempt to exchange knowledge and data in-between component part (and buffer zone) management teams (BEECH POWER, 2021).

4.4. Stakeholder support

Forest management in landscape conservation buffer zones creates a high level of understanding, appreciation and support of the WH beech forests by stakeholders and other actors.

Stakeholders understand, accept and respect the buffer zone management goals and corresponding regulations. They are educated and sensitised about the value and management of buffer zones of WH beech forest component parts. Stakeholders and local actors support and are involved in the management of the landscape conservation buffer zone.

4.5. Sustainable regional development for community well-being

Forest management in landscape conservation buffer zones fosters community well-being in a framework of ecosystem-based regional sustainable development. ES that are essential for the well-being of local people are sufficiently provided and accessible to all.

Human well-being of the local population is enhanced by additional contributions resulting from forest management in the landscape conservation buffer zone.

Additional benefits and added value generated by the WH status are equitably shared amongst stakeholders without compromising anyone's well-being. Regional actors are capable of (regional) sustainable development and actively contribute to it.

In this regard, each management plan should cover the following basic goals (Resolution on National Forest Programme, 2007):

- Sustainable development of the forest as an ecosystem in terms of its biodiversity and all its ecological, economic and social functions.
- Sustainable use of all material resources of the forest for the owner, rural development and the whole society.
- Conservation and development of wildlife populations and their environment.

- Sustainable game management.
- An effective system of communication with forest owners and the public, which ensures the successful direction of forest development.
- A favourable public policy, legislative and institutional environment that will support sustainable forest management and multifunctional use.

Box A1: Slovenian forestry control method

A grid of permanent sampling plots is established across all Slovenian forests, regardless of ownership. Measurements of different forest conditions take place every 10 years. All the trees above 10 cm dbh inside the sampling plot are measured. Growing stock and its increment are measured according to tree species and size classes. Deadwood is also measured, as well as damage of trees. Forest structure and growth conditions are also determined. Monitoring is undertaken in a way that does not harm natural processes.

Alongside detailed data from permanent sampling plots, forest stands are also described on a wider scale (forest sub-compartment), with growing stock, stand structure, tree species, size structure, and developmental phase estimated by forestry engineers (Rules on forest management plans and game management plans, 2020). Descriptions of forest stands provide data for the entire forest area. While describing forest stands, forest engineers also determine measures for tending operations for the next 10 years.

All forestry operations are precisely catalogued. This includes logging, tending, protective, and conservation measures. All collected data is used to analyse past management and evaluate the effectiveness of management actions (e.g. regeneration success).

This data guides decision-making and development of future management plans, guidelines, and actions (Čater and Diaci, 2020a). Constant monitoring and adaptive management ensure the best possible management according to changing site conditions. This control method originated in Snežnik forests at the start of the 20th century and is still in use today (Diaci, 2006).

Box A2: Marteloscopes

Marteloscopes are an option for simultaneous monitoring and research. They consist of a 1-hectare rectangular plot divided in 16 subplots of 25×25 m, where all trees are measured. The recorded tree data includes tree species, location, status (dead/alive), breast height diameter, tree and crown base height, TreMs and an estimation of timber quality. The main focus is on providing insight to stand structures and stand dynamics while individual trees in terms of wood quality, economic and nature conservation value. Through marteloscopes, an estimation for a wider forest area can be made. This method is currently used to some extent in 16 European countries (Schuck et al., 2020).

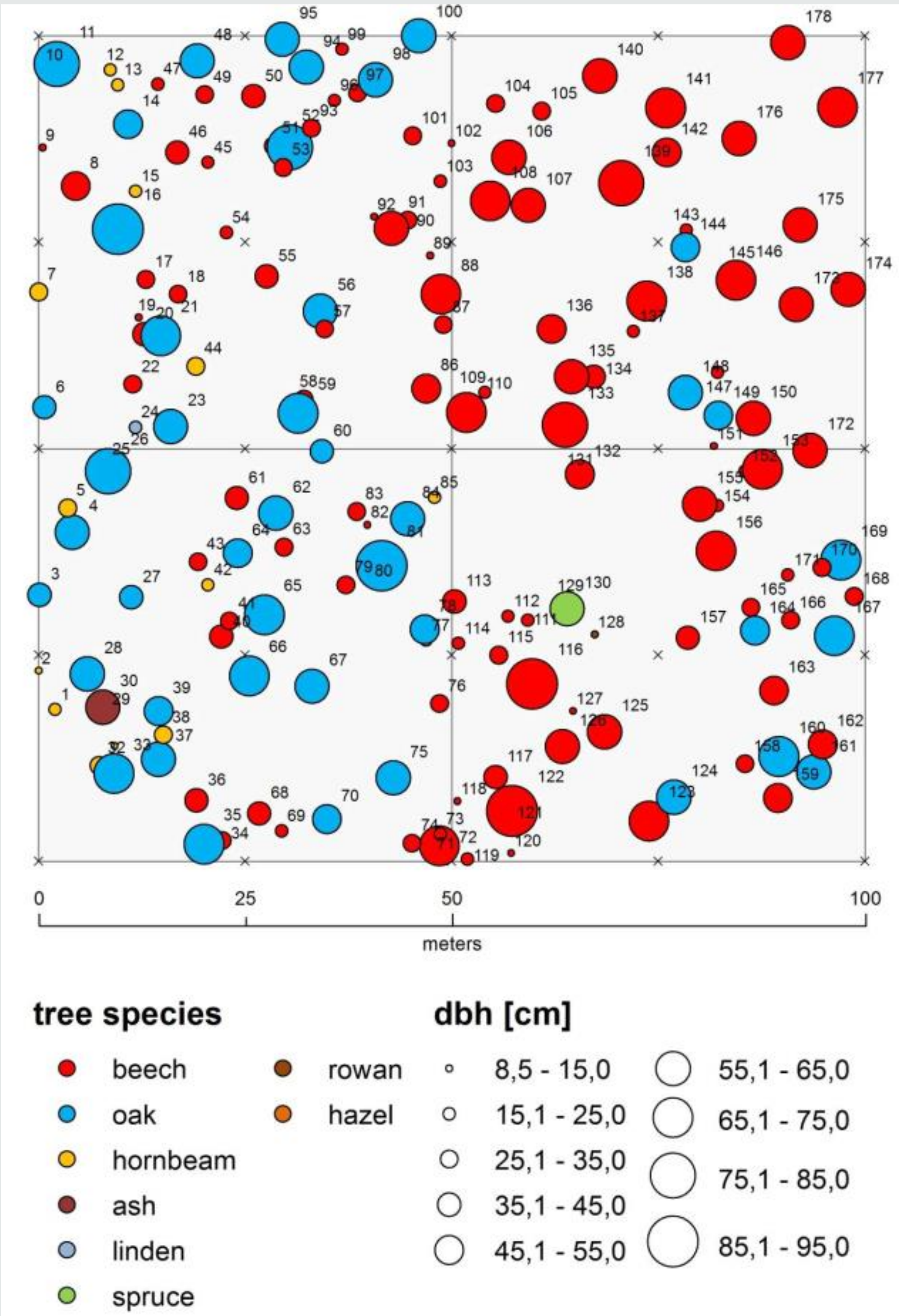

Figure 4: Marteloscope map with all measured trees included (© Vandekerkhove et al., 2015).

5. Criteria and indicators for forest management landscape conservation buffer subzones

The criteria for forest management are thematically connected to the Code of Quality Management, in particular the principle of functional forest ecosystems, relevant for forest management in landscape conservation buffer subzones of WH beech forests. The criteria and indicators should help forest managers to implement an ecosystem-based forest management approach according to the principle. Criteria are based on various literature and best practice examples, with a focus on results from the Workshop on Sustainable Forest Practices (D.T2.3.2). For each criterion, the necessity and function are described and a designated indicator value is proposed, with a threshold value where applicable, to measure the progress of a criterion.

For each criterion, corresponding objectives and a set of proposed strategic actions are presented in the strategy for sustainable, ecosystem-based forest management (O.T2.5).

Any forest management system in the buffer zone needs to take into consideration that the component part has to be ecologically supported by being embedded within functional ecosystems.

The described criteria include ways to develop a natural forest structure, as well as a natural structure of other landscape elements, such as cultural landscape, which can also be present in a landscape conservation buffer subzone.

5.1. Maintenance of a natural forest structure

WHY?

A natural forest structure means a variable forest, with a diversity of both horizontal and vertical structures and the diversity of tree species, corresponding to forest sites. The result is mostly uneven-aged stands with different developmental phases and mixed species of trees, where conditions allow for mixed stands. Natural disturbances and gap dynamics are also an important part of natural forests and their succession phases. Maintaining continuous forest cover is another vital part of ensuring a healthy forest ecosystem, with its variety of ecosystem functions.

HOW?

Forestry should mimic natural processes that ensure the development of uneven-aged stands. The forest management techniques described in the previous chapters should be followed (group selection, individual selection…).

Prohibiting clearcutting is the biggest step towards ensuring continuous forest cover. Clearcutting is a destructive practice that emphasises wood production while neglecting all other ES. Even if logged volume is offset by growth in other areas (replanting, natural regeneration), clear-cut areas remain degraded for a long time. They are more prone to soil erosion and nutrient run-off, which affects soil quality and can impact regrowth. Water retention is also reduced, as the water cycle is disrupted due to a lack of trees. Clear-cut areas can also heat up as much as urban areas. As such, the clear-cut area's climate regulation function is destroyed. This heat can prevent seedling regeneration, especially in the current changing climate with intense droughts and heat waves. It is important to note that forest management is climate management. Biomass retention determines cooling and buffering capacity of forests, while ensuring a working water cycle. As such, forests help regulate climate on a landscape level, which also helps non-forested areas, like settlements and agricultural land (Blumröder et al., 2021).

According to the Guidance Document on Buffer Zone Management (JMC, 2021), clear-cuts are allowed only in exceptional circumstances inside landscape buffer subzones. They are allowed only in accordance with management plans approved for Natura 2000, namely restoration towards natural habitats of non-native forest stands or maintenance of light-demanding native species such as *Pinus sylvestris*. The surface area where clear-cuts may be applied annually must never be bigger than 1 % of the total landscape conservation buffer area at the time. This management practice can be applied in maximum 10 % of the landscape conservation buffer subzone and should be described in an approved management plan, with other practices taking precedence.

The planned possible cut and the extent of cut and extraction of other forest goods should be adapted to the capabilities of forests. Multipurpose use of forests should be aligned with the actual condition and functions of forests and ensure the sustainable functioning of the forest ecosystem. Monoculture stands should be gradually transformed into a natural heterogeneous structure. Altered or degraded forests should be left to follow the natural successive development of forests (Figure 5), with help from artificial regeneration and mimicking natural processes, if necessary. If artificial regeneration is used, site-adapted tree species of appropriate genetic diversity or those derived from locally adapted provenance should be used.

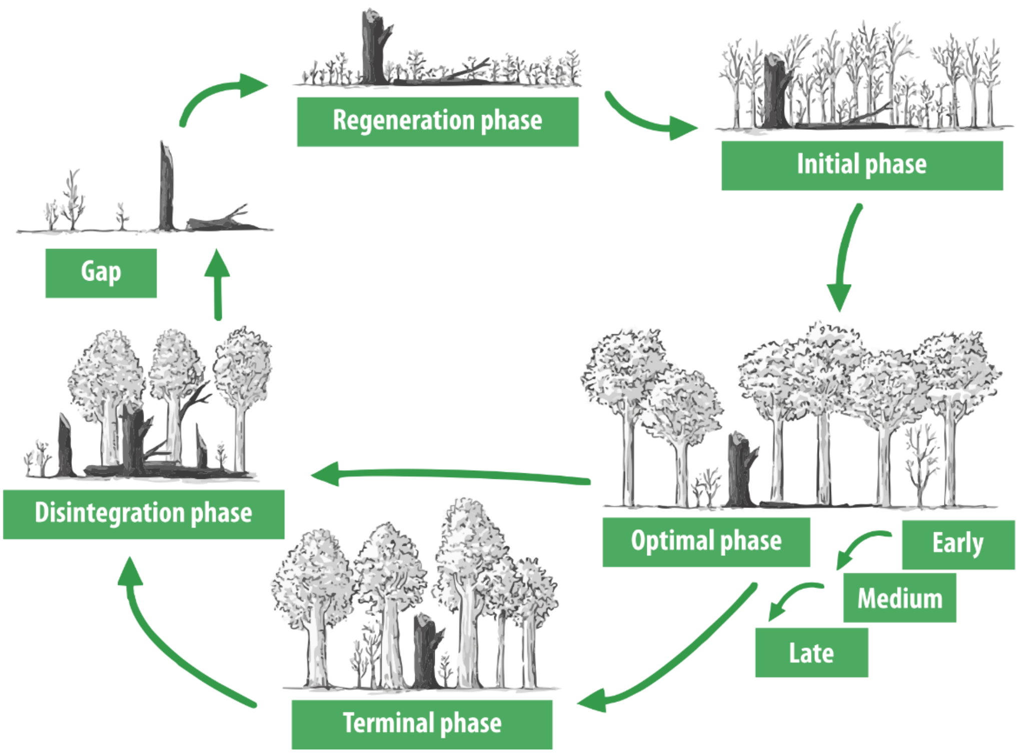

Figure 5: Forest development phases (adapted after Begehold et al., 2014).

INDICATORS

Forest stands should be heterogeneous and uneven-aged, with a variety of trees and other plant species. Trees should be diverse in size and age classes.

Forest cover based on past data is maintained or increased in the long-term. Forest areas are functionally connected (see also chapter **5.7.3 Habitat connectivity**) between each other, based on presence and movement of forest species between forest areas.

Box B1: Mapping a forest's structure

Mapping a forest's structure gives a useful overview of different forest stands and developmental phases of a forest, and helps guide management decision in ensuring a natural forest structure is present in the forest. Figure 6 shows an example from component part Snežnik, where different forest stand types are mapped. Forest stand types (e.g. Decidious type) are further divided according to different development phases and species composition.

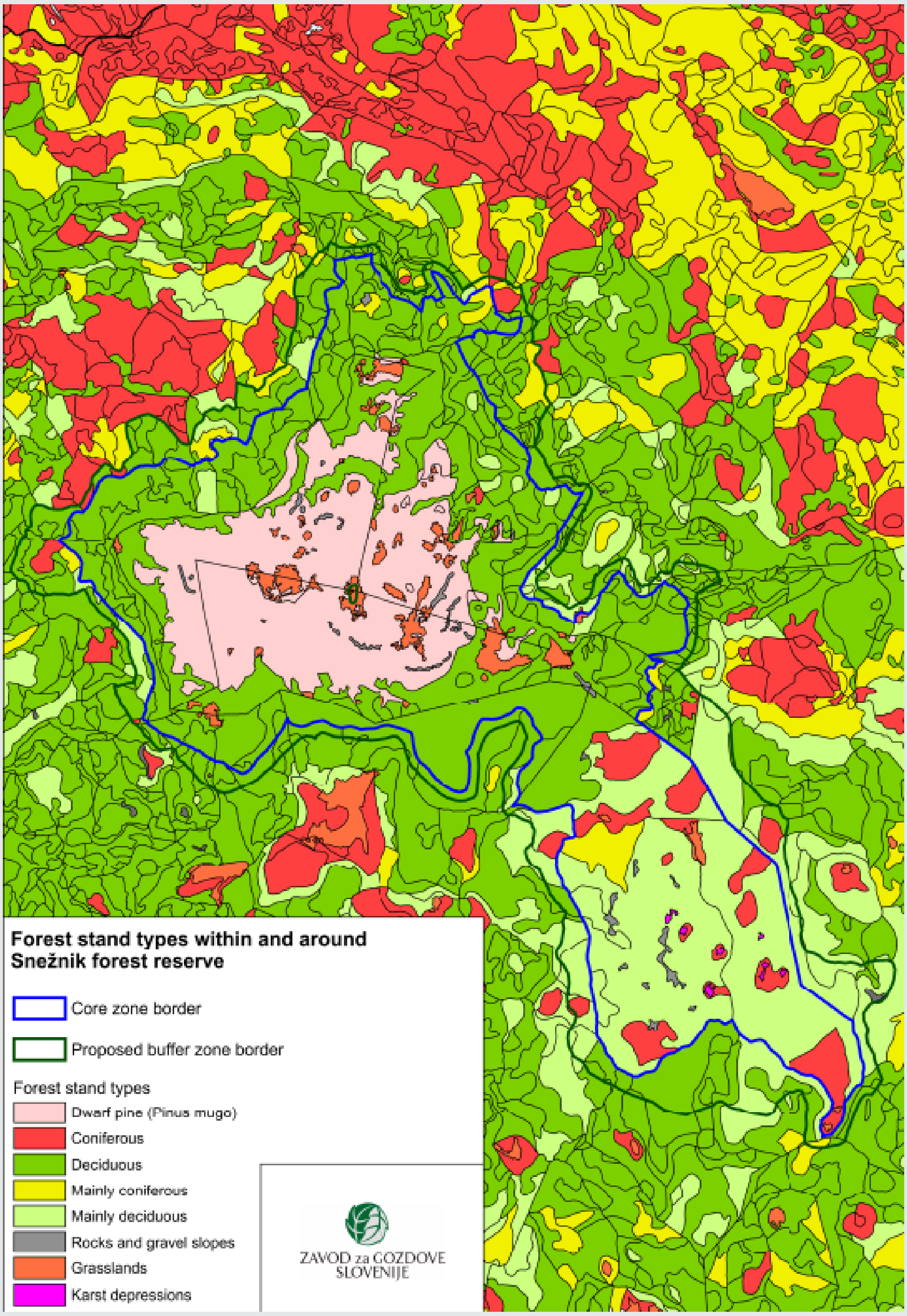

Figure 6: Forest stand types in component part Snežnik (© SFS / Urban Prosen).

5.2. Promotion of natural regeneration

WHY?

All tree species in the beech forests of landscape conservation buffer subzones should ideally be naturally regenerated. The various naturally occurring tree species should be continuously present to promote biodiversity (Winter et al., 2020). Hunting should be consistent with this goal, as to prevent overgrazing of certain plant species (see chapter **5.9.1 Hunting**). If natural regeneration is not possible (e.g. due to climate change, game grazing etc.), these negative impacts have to be solved. Artificial regeneration should be used only where, despite efforts, natural regeneration cannot be achieved. Artificial seedlings must have genetic material from the same or adjacent beech forest region where regeneration is taking place (JMC, 2021).

HOW?

Natural regeneration is constantly present in vital forest stands. Depending on stand structure and environmental conditions, regeneration can be either fast or slow (Čater and Diaci, 2020a). Monitoring natural processes and adapting management and logging to them can help maintain sustainable natural regeneration at a desired level.

INDICATORS

Percentage of tree regeneration that is natural. E.g. Slovenian forests have up to 95 % of natural regeneration (see chapter **6.3 Slovenian Forestry School**).

5.3. Avoidance of non-native tree species

WHY?

To ensure buffer zones' protective function, it is vital for them to retain as natural a structure as possible. Non-native tree stands can change the soil structure, decomposition processes, and the biocoenosis of soil organisms (Winter et al., 2020). Non-native tree species have the potential to spread from the buffer zone inside the component parts, which can threaten the OUV of the property.

HOW?

Non-native tree species are not promoted by management inside the buffer zone. Existing non-native stands should ideally be gradually restructured into natural stands with native tree species.

INDICATORS

Management plan forbids the promotion of non-native tree species inside the buffer zone.

Management plan defines a strategy for restructuring existing non-native stands into natural native stands.

5.4. Optimisation of growing stock

WHY?

Forests play a key role in the global carbon cycle, with the removal of carbon dioxide (CO_2) from the atmosphere. Purposefully increasing growing stock per hectare ensures a higher level of CO_2 uptake, which increases the carbon sequestration function of forests. Forests have a great potential in absorbing CO_2 emissions and mitigating effects of the climate crisis. The increase in growing stock also makes forests more resilient to environmental changes, e.g. extreme weather events. Increased growing stock is also important for biodiversity.

HOW?

With proper planning and a silvicultural system, it is easy to ensure a continuous increase in growing stock, especially in state forests. It should ideally be increased by natural regeneration.

Box B2: Resolution on National Forest Programme (Slovenia)

In Slovenia, the forest growing stock has been steadily increasing for the past 60 years. As such, forests' growing stock is around its optimal level to balance all the necessary forest functions. The current National Forest Programme states at least 75% of the annual increment should be logged to prevent over-aging (risking stand stability) and ensuring enough of the forest can sustainably and naturally regenerate.

Measuring the growing stock is part of a regular monitoring system. Monitoring can be the purview of different institutions, depending on national organization of different countries. These can be park or reserve administrations, state forest services, private research companies, or universities and other scientific institutes.

Planning the increase of growing stock should also take in mind the economical function of forests, in order to ensure quality wood assortments, while still increasing growing stock. The goal value for growth stock differs depending on site conditions, therefore it is not useful to define a universal indicator value. Growing stock goals in the buffer zone should be defined according to the natural biomass conditions inside their relevant old-growth component parts.

The final goal is not only increasing growing stock, but **optimising** it to balance different forest functions. Stand stability and sensitivity can be affected by too much growing stock, which can threaten the protective buffer function of forests (Diaci, 2006). Therefore, increasing growing stock has its upper limit, based on site conditions and the threat of extreme weather events that can cause mass damage to older forests. Reference values should be taken from undisturbed core zones, as those are the natural cycles we are trying to imitate. But we should keep in mind managed forests have a smaller amount of late forest development phases (terminal phase, disintegration phase) in order to ensure sustainable regeneration of stands and economic functioning. Too much growing stock can prevent adequate regeneration of stands (Bončina, 1994). Therefore, the goal value for optimised growing stock should be lower than growing stock in the referenced old-growth core zone.

INDICATORS

Forest management optimises growing stock according to site conditions and risks from climate change. If possible, increasing growing stock can be monitored.

5.5. Maintenance of diverse forest edges

WHY?

Forest edge might seem unimportant from a forest management perspective, but it is a vital transitionary habitat between forests and open country. As such, it supports a high variety of species and is important for preserving forest biodiversity (Papež et al., 1997). A well-structured forest edge can increase the resilience of both forests and open country, e.g. by acting as a windbreak.

HOW?

Forest edge should be heterogeneous and diverse in structure and plant species. It should extend both inside the forest stand and in the open country. It should be composed of a high variety of tree species, herbaceous plants, and shrubs. The outer edge should ideally border on an extensively managed grassland, to further improve connectivity between forest and open country (Winter et al., 2020).

INDICATORS

Forest edge is structurally diverse and supports a variety of tree, herb, and shrub species, appropriate for site conditions.

Figure 7: A structured forest edge in Germany (© Wikimedia Commons / Pavel Sredin).

5.6. Maintenance of farmland wooded elements

WHY?

Certain landscape conservation buffer subzones are not composed only of forests, but also include cultural landscapes, e.g. farmland and pastures. A vital part of traditional cultural landscapes are hedges and smaller patches of trees, as well as old individual trees. Similar to a forest edge, they are composed of a wide variety of tree, herb, and shrub species and support a high diversity of animal life. As such, they provide an important habitat for wildlife and play an important connectivity function, which also strengthens the resilience of forests (see chapter **5.7.3 Habitat connectivity**). Their services include climate regulation, flood and erosion prevention, wind sheltering, soil formation, pollination and pest control, among others (Lešnik, 2018). Wooded elements therefore provide benefits both for biodiversity and for agriculture (Papež et al., 1997).

HOW?

Area managers should cooperate with relevant stakeholders to ensure preservation of traditional cultural landscape elements. Stakeholders should be educated about the importance of hedges and isolated trees and tree patches, and the benefits they gain from maintaining those forested structures in their land. If possible, financial schemes should be set up to support stakeholders in restoring degraded hedges and maintaining existing ones.

INDICATORS

A diverse structure of open country in the landscape conservation buffer subzone. Hedges and small tree patches are present in the landscape, and ecologically connected between each other and the bigger forest area. Old individual trees are protected.

Figure 8: Cultural landscape in Belgium with diverse wooded elements (© Wikimedia Commons / Gilles San Martin).

5.7. Conservation of biodiversity

Forests are home to most of the world's terrestrial biodiversity. As such, they are a vital instrument in stopping the loss of biodiversity. The following criteria aim to present measures to increase and conserve forest biodiversity. Since 25 % of forest biodiversity is connected to deadwood (Larrieu et al., 2012), this is a major criterion. It is important to note that the following criteria are not mutually exclusive, but can overlap to an extent. For example, habitat trees include deadwood elements and therefore overlap with the criterion on deadwood. The same is true for old-growth patches. Managers should take this overlap into account when preparing management plans and collecting data.

5.7.1. Deadwood volume

WHY?

Standing deadwood (snags) and fallen deadwood (coarse woody debris) are vital parts of a healthy forest ecosystem. Deadwood provides a variety of functions, among them soil stabilization, nutrient cycling, carbon sequestration and food, habitat and shelter for forest species. At least 25 % of all forest species rely on deadwood, from fungi, plants, invertebrates, to birds and mammals (Larrieu et al., 2012).

HOW?

Intentionally leaving a certain amount of dying and dead wood in tree stands, based on monitoring data of current amounts of deadwood. Only deadwood above 15 cm dbh (diameter at breast height) should be counted (JMC, 2021).

Larger trees (dbh > 40 cm) are more important as snags (standing deadwood), while smaller trees are more common as fallen deadwood. Older trees should be left in the forest to decay naturally.

Deadwood can be retained through different logging tactics. Logging remains should be left in the forest as deadwood. This should not include only branches removed from a logged tree trunk.

Tall stumps, short stumps, split trunks, thick branches, lying trunks and other deadwood structures all provide different microclimate and microhabitat requirements. A diversity of different types of deadwood should be ensured as much as possible. Differences in tree species, size, degree of decomposition, bark, sun exposure and humidity, all affect which species community will form. As such, diverse deadwood is needed to ensure high biodiversity, especially for different decomposer species (Winter et al., 2020). Living trees with dead structures are also important (see chapter **5.7.3.2 Habitat trees**).

Box B3: Examples of deadwood retention

Management in the Sonian Forest (Belgium) allows a maximum of 16 metres of a logged tree to be removed, while the rest of the trunk must stay in the forest as fallen deadwood.

Certain forest managements in Germany only allow the logging of trees to take place at chest height, so the stump is left as standing deadwood (Winter et al., 2020).

Actions not connected to logging can also ensure higher deadwood. Preserving smaller old-growth stands in logged forests, forming »old-growth patches« that are left unmanaged, increases deadwood volume alongside habitat connectivity (see chapter **5.7.3 Habitat connectivity**).

JMC recommends at least 30 m^3/ha of deadwood or 10 % of growing stock. The pace required to reach the deadwood target depends on the biogeographical conditions, development stage of the forest stand and the tree species composition in landscape conservation buffer subzone. Young stands do not have a dead wood volume target (JMC, 2021). Care must be given to understand the site conditions for each specific landscape conservation buffer zone. The variety of beech forest sites and climatic conditions means numbers will vary between sites. Undisturbed old-growth core zones in each protected area should be used as references for that area’s natural growing stock and deadwood amount. According to a study by Christensen et al. (2005) the mean value of deadwood in European beech forest reserves is 130 m3/ha.

INDICATORS

The goal is **at least 30 m^3/ha or 10 % of standing and fallen deadwood** (JMC, 2021). Standing deadwood ideally made up of trees bigger than 40 cm dbh (diameter at breast height) where natural conditions allow for such sizes. Fallen deadwood is made up by a variety of all size classes. Wherever possible, deadwood volume should be continuously increased.

Confirmed presence of indicator species for old-growth beech forests. Indicator species should be site-specific, based on available data, e.g. Natura 2000 species.

Figure 9: Deadwood in a primeval forest in Ukraine (© FAO/Jan Husák).

5.7.2. Quiet zones

WHY?

Quiet zones are wider areas of forest, where activities that disturb or endanger wildlife are limited. Quiet zones limit disruptive human activities, such as logging, wood transport, and recreation activities. Limitations can either be spatial or temporal, depending on the species targeted (Žitnik et al, 2018). They are a useful tool in helping to protect nesting areas and dens of endangered species (spatial quiet zones) or restrict forestry activities while certain species are most vulnerable (temporal quiet zones).

HOW?

By monitoring endangered species, we can determine areas important for them. These are especially feeding, resting, nesting sites and migration paths. We can limit the access to these areas by closing forest roads and adapting forest management, so no forestry work takes place in those zones. The size and duration of quiet zones depend on the species we want to protect.

Alongside forestry work, we should also limit social activities of forest visitors in quiet zones. Recreation, tourism and education activities should be directed away from quiet zones.

INDICATORS

Mapped locations of important areas for different protected species.

Quiet zones established according to monitoring data, where human activity is limited.

Box B4: Guidelines for quiet zones (Slovenian FMP)

Slovenian forest management plans integrate nature conservation measures according to Rules on Forest Protection (2016). These measures are planned and implemented in all Slovenian forests, not just Natura 2000 areas. Examples of quiet zones for different species are given below.

Hazel grouse (*Tetrastes bonasia*): a 400 m radius around known nesting sites should be established. From April to July, no forestry activity should take place in this zone (SFS, 2011).

Ural owl (*Strix uralensis*): a 300 m radius around known nests should be established, where no forestry work is allowed to take place between February and July, to ensure nesting goes undisturbed (SFS, 2011).

Golden eagle (*Aquila chrysaetos*) and white-tailed eagle (*Haliaeetus albicilla*): a 500 m radius around nests should be established between January and July, where no forestry work is to take place (Rules on Forest Protection, 2016).

Radius can be adjusted in the field, depending on terrain and conditions.

Other similar guidelines exist for other species of owls, birds of prey, grouse, as well as for storks, egrets, ungulates and carnivores.

Known areas of importance for protected species should be mapped and included in forest management plans. Quiet zones should be established every season, monitoring should ensure data on new and old areas of importance. New forest infrastructure (e.g. forest roads) should not be build inside known quiet zones or areas of importance for endangered species.

5.7.3. Habitat connectivity

According to the **Guidance document on buffer zone management and buffer zone zonation** (JMC, 2021), the component part should be ecologically connected to other (beech) forests and other highly functional ecosystems, (even beyond the buffer zone). For this reason, connectivity between habitats is another important factor in maintaining resilience in populations and the wider forest ecosystem. We must recognize different macro-habitats within a forest ecosystem as patches to be connected (i.e. old-growth islands in a managed forest). Connectivity facilitates crucial ecological processes such as seed dispersal, gene flow and ecosystem resilience.

The connective functions require specific management regulations in order to establish a consistent and functional ecological network. The network focuses on conserving and fostering late-successional structural elements and late forest development phases (terminal phase, disintegration phase) in order to provide connectivity and continuity of such natural forest elements (JMC, 2021).

Increasing habitat connectivity, in terms of a wider forest system, can take place through forest regeneration, natural regeneration of non-forested areas into forest (increasing forest cover), establishing larger forest corridors (connecting bigger forest areas with wooded corridors), and changing altered forest stands (monocultures) into a more natural state (see chapter **5.1 Maintenance of a natural forest structure**). The connective function within a landscape conservation buffer subzone should aim to ensure a functional ecological network between different forest areas and reduce isolation and fragmentation of forests within the landscape conservation buffer subzone.

In order to provide connectivity between late-successional structural elements and late forest development phases (JMC, 2021), a functional network of old-growth habitats **within forests** should also be established. Two ways to do this are old-growth patches and habitat trees. Such elements should ideally be distributed over the whole buffer subzone as much as possible.

5.7.3.1. Old-growth patches

WHY?

Old-growth patches are a good way of increasing connectivity between macro-habitats within a managed forest. They aim to serve as "old-growth islands" between larger old-growth areas to increase connectivity between them. Increased connectivity means better resilience of species dependent on these areas.

We recognise two types of old-growth patches:

- **Set-aside patches** are smaller areas within a forest that are permanently delineated to conserve or develop old-growth stages through non-intervention.
- **Senescence patches** (i.e. extended rotation patches) are areas that remain managed but are deliberately delineated to develop old stands by significantly extending the rotation period or excluding final harvest (JMC, 2021). These have a temporary period of non-intervention of a minimum 20 years.

HOW?

The size of an old-growth patch should be at least 5 hectares. It's better to have one larger patch than a few smaller ones (Žitnik et al., 2018). They should be established in areas of low disturbance, areas with no economic interests, areas where indicator species are already present or areas where old-growth characteristics are already present. They should be established as "stepping stones", ecologically connected between each other and larger protected areas, not isolated. Aggregated habitat trees should not be considered as patches, because the surface area is much smaller. While set-aside patches have a permanent non-intervention regime, senescence patches have a temporary period of non-intervention of a minimum 20 years.

If the surface of the buffer zone is less than 5x the surface of the component part, then 10 % of the landscape buffer area should be established into old-growth patches (set-aside or senescent).

If the surface of the buffer zone is more than 5x the surface of the component part, then at least 3 % of the landscape conservation buffer area should be established into old-growth patches (set-aside or senescent) (JMC, 2021).

Which areas of the landscape conservation buffer subzone are appropriate for set-aside or senescent patches should be the decision of the manager, based on ecological knowledge and data. A map of all set-aside and senescent patches should be included in the management plan. Mapping helps decide the adequacy of the activities (see also **Box B6**).

INDICATORS

Established matrix of old-growth patches. **3 % or 10 % of the buffer zone area**, depending on the size of the buffer zone in relation to the component part. Patches are properly marked and mapped. Patches at least 5 ha in size.

5.7.3.2. Habitat trees

WHY?

Habitat trees are another smaller landscape element of habitat connectivity. Habitat trees and the microhabitats they host are of prime concern for forest biodiversity as they can harbour many endangered specialised species of flora and fauna. Many of them belong to the most threatened organisms in European temperate forest ecosystems (Bütler et al., 2013). Density of habitat trees with a diameter of over 70 cm remains less than 0,5-2 trees per hectare in managed forests (Bütler et al., 2013), whereas 10-20 such trees per hectare occur in virgin forests in Central Europe and southern Scandinavia (Nilsson et al., 2002).

HOW?

Habitat trees should intentionally be excluded from logging plans. If this measure is to take place in a private forest, a financial scheme should be established for private owners to compensate for the lack of logging revenue. Selected habitat trees should be properly marked and mapped and inventoried in a common database. If a database does not exist, then habitat trees should at least be marked as such in the field, e.g. by a painted symbol pronouncing them as habitat trees.

Habitat trees should not be the most valuable trees, most productive, or trees at most accessible sites (Bütler et al., 2013). They should be microhabitat-bearing trees (including dead snags) or non-vigorous low quality trees, which would be removed under conventional uneven-aged management.

Generally, a combination of dispersed and aggregated retention of habitat trees is recommended (‘variable retention’). Aggregated habitat trees provide better habitat for birds than scattered individual trees. However, where scattered individual habitat trees already exist, they should be retained.

Trees likely to bear microhabitats in the future should be selected for “recruitment”; they should be properly identified and permanently protected from harvesting (Bütler et al., 2013).

At the stand level, at least 5 habitat trees per hectare are needed (JMC, 2021). Habitat trees should be at least 40 cm in diameter. All 80+ cm trees should be left standing (Krumm et al., 2020). These so-called “Methuselah” trees are important for biodiversity, especially flightless beetles and rare fungi. They are particularly rich in microhabitats (Winter et al., 2020).

A diversity of different habitat trees with different microhabitats is needed. Some microhabitats are more important than others, but a diversity of them is needed to support a wide range of taxa (Asbeck et al., 2020). Habitat trees should be evenly distributed over the whole area, as to prevent isolation and loss of biodiversity from species with poor dispersion capabilities (e.g. flightless invertebrates, sedentary birds…) (Winter et al., 2020).

INDICATORS

At least **5 selected and properly marked habitat trees per hectare**. Selected habitat trees with a variety of different sizes, tree species, shapes and microhabitats (e.g. presence of tree fungi and cavity-dwelling species).

Box B5: Field Guide to Habitat Trees

A publicly available "*Field guide to tree-related microhabitats*" has been developed by Bütler et al. (2020). It is available through the *Swiss Federal Institute for Forest, Snow and Landscape Research* (WSL) at the following URL: https://www.wsl.ch/de/publikationen/field-guide-to-tree-related-microhabitats-descriptions-and-size-limits-for-their-inventory.html

It describes 47 different tree-related microhabitats, divided into seven types.

Concrete examples of habitat trees include: nesting trees with nests and cavities, resting and singing trees for grouse species, rare and fruitful tree species, large trees with irregular shapes, trees with injuries (cracks, breaks, loose bark), trees with deadwood or decay (e.g. dead branches, dead canopy crowns), and trees with epiphytes (ferns, fungi, lichen, moss) or sap runs.

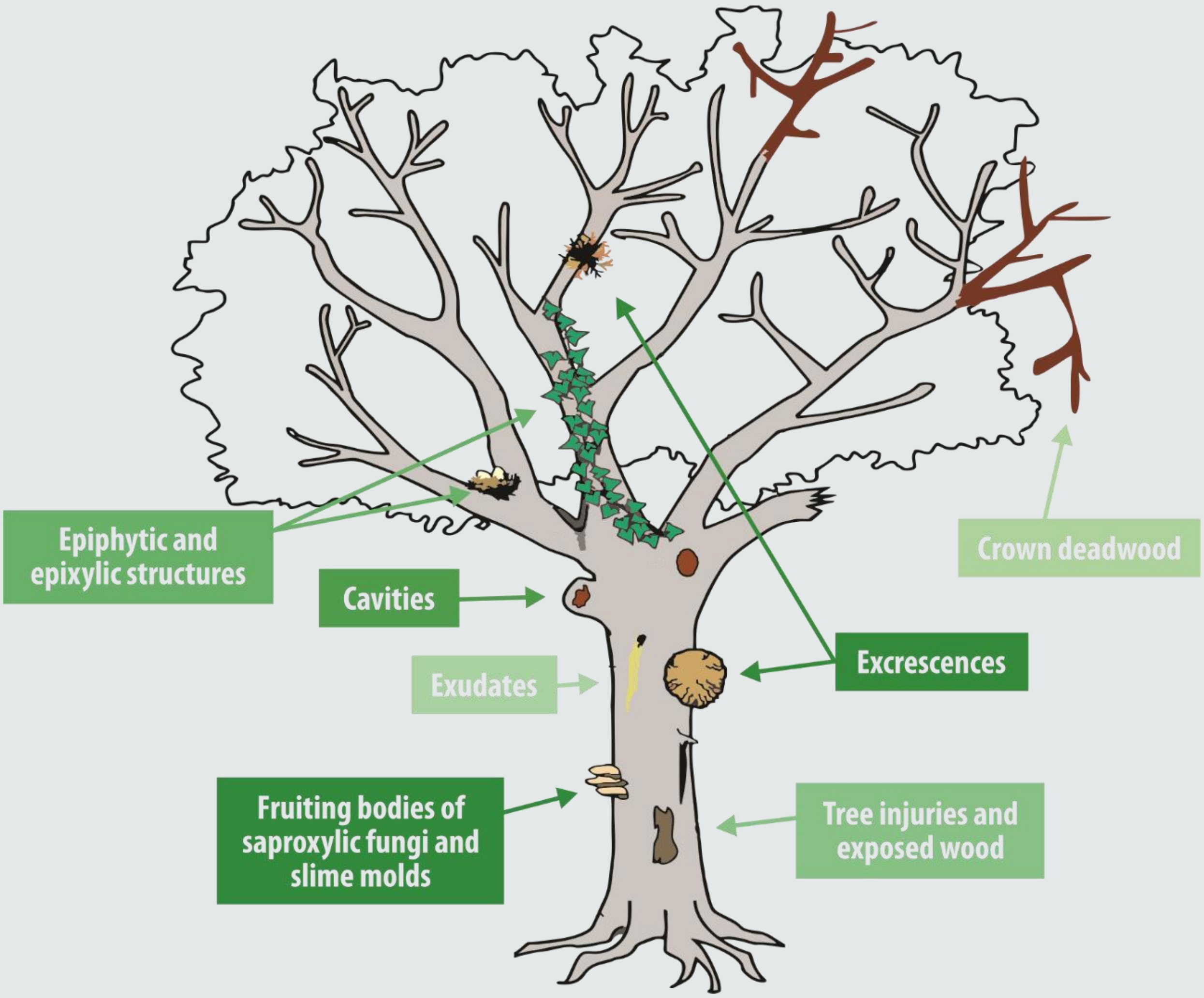

Figure 10: Seven types of different microhabitats on a habitat tree (adapted after Bütler et al., 2020).

Figure 11: Examples of different habitat trees (© Flickr / Bill Higham, James Petts, Sergey Pesterev).

Box B6: Map of biodiversity measures

Mapping biodiversity measures gives a useful overview of the efficacy of management and the distribution of connective elements. Mapping can help guide management decisions to ensure connective elements are evenly distributed throughout the forest area. Figure 12 shows an example from component part Snežnik.

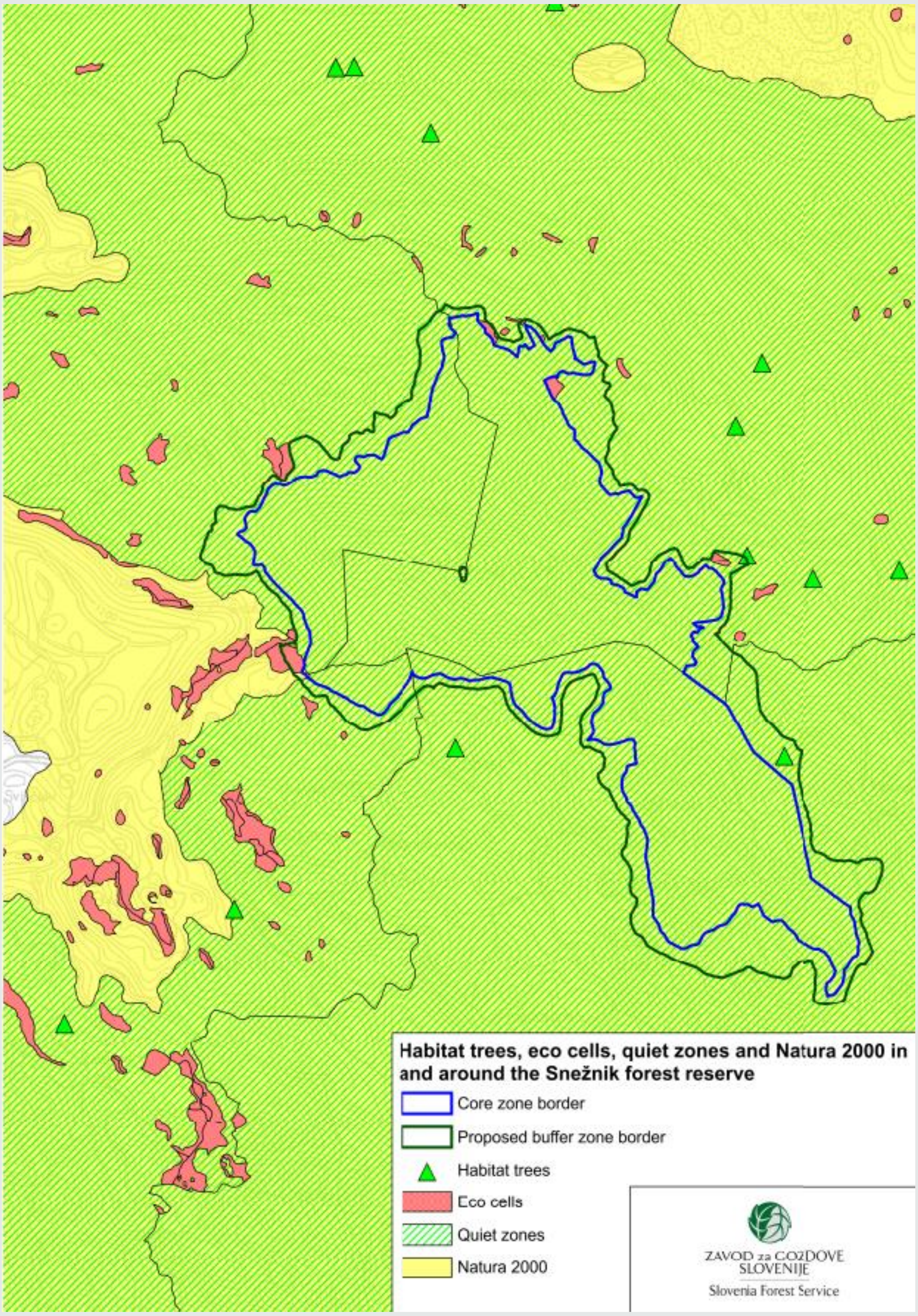

Figure 12: Map of different biodiversity and connectivity measures (© SFS / Urban Prosen).

5.7.4. Terricole structures

WHY?

Terricole structures are naturally formed ground structures, such as large boulders, root plates, etc. that should be preserved by management. Different terricole structures support different species, but are mainly vital for the propagation of fungi, moss, and lichen. Several are described below, most adapted after Winter et al. (2020).

Moss cushions: larger areas of moss are a vital habitat for hundreds of fungi and invertebrate species, due to their water and soil retention. Their hydrological dynamics are also important for certain higher plants.

Large boulders: these are stones bigger than 1 meter, that are clearly distinct in the forest. They serve as as important growth surfaces for moss and lichen. They help retain moisture which helps the growth of fungi and plants. They can serve as hiding places for reptiles and amphibians, and feeding places for birds.

Root plates: these structures form when a tree falls over and its root network is torn out of the ground. They serve as rare habitats for pioneer fungi species, reptiles and amphibians. Even larger mammals, like the European wildcat (*Felis silvestris*), use them for hiding and resting.

Erosion structures: small-scale erosion structures on slopes create many microhabitats that are important for the propagation of moss, lichen and fungi due to their soil properties. Wet erosion structures are also a great habitat for ferns and horsetails.

Springs: depending on chemical conditions of a spring, different rare fungi are supported on its banks, alongside ferns and horsetails. They are also important for invertebrate species (insects, worms…) that use springs as reproduction and feeding grounds.

Cave entrances: caves can be ubiquitous in certain areas (e.g. karstic landscape). They can provide shelter for wildlife and offer unique microhabitats not found elsewhere.

HOW?

Forestry works should take into account the many terricole structures present in the forest when constructing forest roads, skidding trails and undertaking other forestry operations. Since these structures mostly cannot be mimicked by management, it is important to preserve them as much as possible.

INDICATORS

Management plan acknowledges the importance of terricole structures and sets guidelines to preserve them.

Figure 13: Large boulders full of moss are a good example of terricole structures (© Pixabay / Hans Braxmeier).

Figure 14: Small erosion structures can offer important microhabitats (© Pixabay / Michael Mueller).

5.8. Protection of intangible benefits

The criteria for intangible forest benefits mainly focus on soil and water quality. These are vital elements for a healthy forest ecosystem, but they also provide benefits for humankind. Forests provide clean water for communities, while also safeguarding against erosion, landslides and soil degradation.

5.8.1. Soil and water protection

WHY?

Soil protection is important for long-term fertility of forest stands, as soil quality is inseparable from forest quality. Soil is an important microhabitat and a recycling system for nutrients. Degraded soil is not easily revitalized, so appropriate management is vital (Cambi et al., 2015).

Adequate management for water protection is important in the whole managed area, but especially pronounced in areas with springs, rivers, streams, wetlands and other water bodies. Management should ensure a forest structure that provides water retention and reduces flood and erosion risks and creates no negative impacts on water quality in a forest area (e.g. pollution, infrastructure…). Certain water bodies also serve as important habitats for forest species.

HOW?

Soil protection includes maintaining constant forest cover and measures against clearings that could promote unwanted erosion processes. Forestry should focus on small-scale actions and maintaining a heterogeneous forest structure and promoting the protective function of forests (SFS, 2011). Logging debris (branches, stumps, roots…) should be left in the forest to enhance soil productivity.

Special care should be given to forestry operations on sensitive soils and erosion-prone areas as well as in areas where operations might lead to excessive erosion of soil into watercourses. Techniques applied and the machinery used shall be suitable for such areas. Special measures shall be taken to minimise the pressure of animal populations on these areas (see chapter **5.7.2 Quiet zones**) (PEFC, 2018).

Skidding trails for forestry operations should be constructed in a way that damage to soil and water is minimised. Valuable habitats should be preserved as much as possible (see chapters **5.7.3.2 Habitat Trees** and **5.7.4 Terricole structures**).

Water retention is provided by a rich forest undergrowth that increases water storage capacity. Due to this, a heterogeneous forest structure should be maintained and forest cover increased.

Deadwood and growing stock also increase water retention. Water should be retained in forests as much as possible. Wetlands and water bodies should be preserved. Springs should be especially protected, by avoiding logging in their vicinity, avoiding draining or tapping the spring and by not modifying their structure (Winter et al., 2020). Flood and erosion prevention is ensured primarily by maintaining constant forest cover. Water quality is maintained by a variety of different management actions. These can depend on national legislation. Water quality should be defined according to local/national biochemical criteria.

INDICATORS

Measures to protect soil from compaction, erosion, etc. while harvesting, with use of appropriate logging techniques and machinery.

Water sources appropriately protected according to relevant legislation.

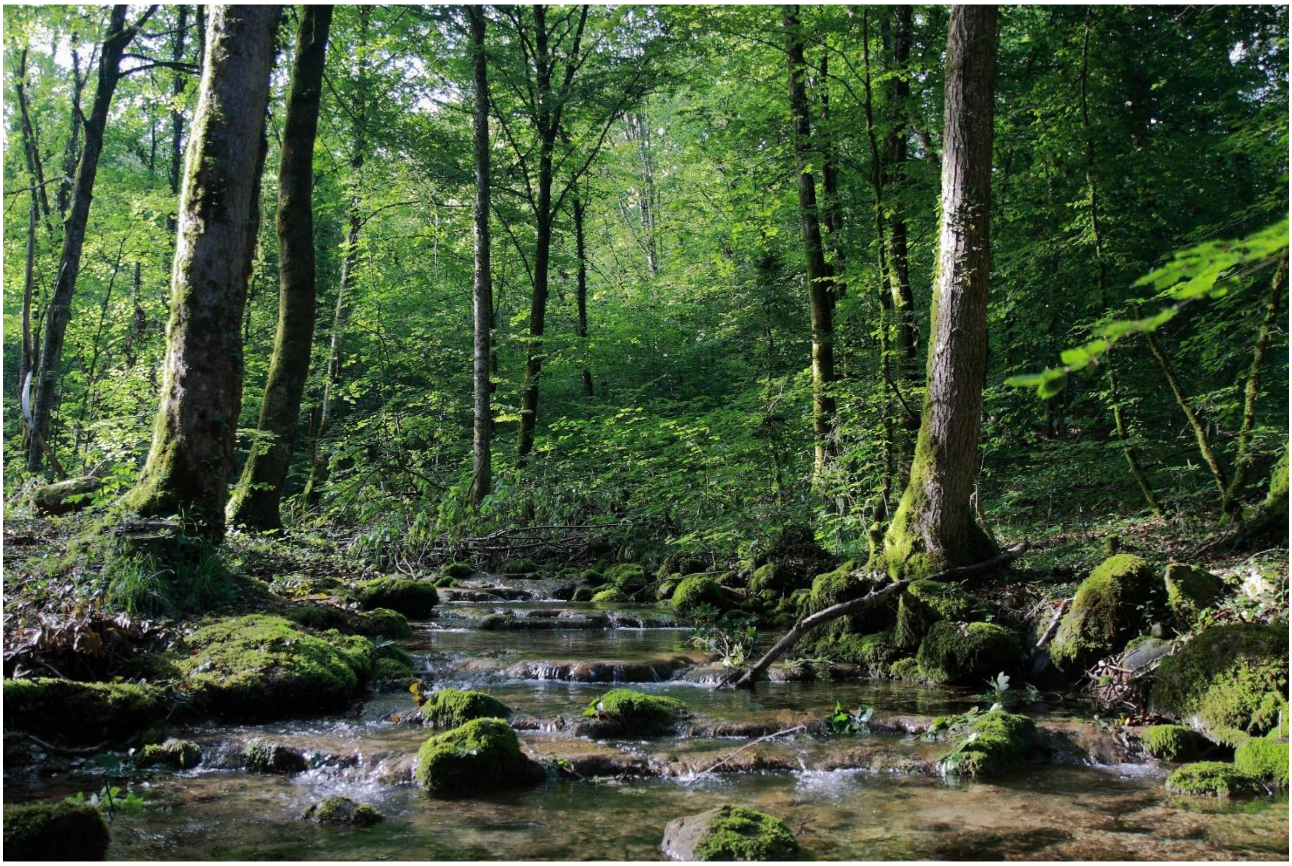

Figure 15: Water bodies perform a variety of important functions in forests (© FAO/Julia Kelly).

Box B7: Guidelines in forest management plans (Slovenian FMP)

Heavy forestry tractors are suitable on difficult terrain, but their use should be limited elsewhere, as to not cause unwanted damage to soil. Lighter tractors are recommended on easy terrain. Logging should be planned according to different conditions, such as growth and weather conditions to limit damage to undergrowth and soil. Tractors should not move outside of established skidding trails and forest roads.

It is recommended if possible, to use trailers to transport wood to the collection area, instead of dragging logs. This reduces soil movement and damage to skidding trails.

Machine logging (e.g. with "harvesters") should be carefully planned depending on growth conditions in a forest. In stands with weak stability, young broadleaf stands, stands full of saplings etc., the use of machine logging is discouraged (SFS, 2011). It is also discouraged on terrain that is wet, boggy, steep or prone to erosion. Machines should only move on established trails. Branches of logged trees should be placed on these trails to reduce soil damage. Machine logging is recommended for large scale sanitary cuts in case of extreme weather events, when large amounts of wood have to be cut.

Constructing forest roads and trails should follow similar guidelines to prevent erosion and damage to stands and hydrological function. Trails on steep terrain should be especially carefully planned, with an additional assessment of possible negative effects (SFS, 2011).

Box B8: Examples to ensure water quality (Slovenian legislation)

Infrastructure, transport, storage of wood and refuelling in the immediate vicinity of water bodies should be forbidden. A distance of at least 25 m from water bodies should be ensured for all such activities. Poisonous substances (paints etc.) and biocides should not be used, especially near water sources. Salt licks for hunting must be placed at least 50 m from water sources. Water bodies must not be modified or altered in ways that change the water quality. Logging equipment (chainsaws) must use bio-degradable lubricants. Other machinery must have equipment to prevent or clean up oil spills. Riverine vegetation should not be used for wood production. A riparian corridor of 10-30 m on each side of a water body (e.g. river) should be left to maintain ecosystem functionality. Water bodies must be mapped in forest management plans (Rules on Forest Protection, 2016).

5.8.2. Avoidance of biocides and fertilisers

WHY?

Biocides and fertilisers have a serious impact on forest communities. Especially invertebrates, which make up the majority of forest fauna, are negatively affected (Winter et al., 2020). They can also pollute water bodies, degrading water quality for wildlife and human use.

HOW?

No biocides, fertilisers, or other poisonous substances should be used in the buffer zone. Management should ensure this by specifying these limitations in the management plan. Stakeholders (e.g. private owners) should be made aware of the limitations and the reasons for them.

INDICATORS

Management plan forbids the use of biocides and fertilisers for forestry in the landscape conservation buffer zone.

Stakeholders aware of limitations and reasons for them.

5.9. Species management

Active species management is sometimes necessary for preserving a forest's health and, in the case of WH, for preserving the Outstanding Universal Value. The criteria here describe measures against overabundant game species and invasive alien species. These are the biggest biological threats facing healthy natural forests and our WH.

5.9.1. Hunting

WHY?

Game species are a crucial component of forest ecosystems, but their overabundance can cause issues. Overgrazing can influence the structure of forests, stand regeneration and growth of seedlings. Some tree species are more affected than others, which can cause artificial imbalances in forest structure.

HOW?

Hunting guidelines and restrictions in the buffer zone should be defined in the management plan. They should be planned according to the size of the buffer zone (E.g. there is no hunting in buffer zone Borovec

(Slovenia), as the area is small enough for management to achieve all its hunting objectives outside the buffer zone).

Monitoring of game impact is strongly recommended. Game management should only be applied if game density is increased by anthropogenic factors like feeding, nearby agricultural areas etc. or because of the presence of invasive alien species (JMC, 2021).

Selective hunting is in some cases (primarily bigger buffer zones) needed to reduce negative effects of overabundant species, e.g. overgrazing, which reduces the natural regeneration ability of certain tree species, or the spread of disease. It is important to note that healthy populations of apex predators (lynx, wolf) also help in this regard, as they also perform the function of population control on a variety of other animals.

INDICATORS

Monitoring of wildlife and game impact established.

Maintain or establish the harmonization of herbivorous game populations with the environment.

5.9.2. Invasive species management

WHY?

Invasive species can have serious adverse effects on their invaded habitats, with major economic and environmental damage. They are a threat to native biodiversity and can even drive native species to extinction. Since they usually have no natural ecological barriers in their introduced environment, they can spread rapidly. Therefore, a well-planned management system is necessary to limit their effect on the environment.

HOW?

Active management (e.g. removal) of invasive species and human introduced pests to protect the OUV and integrity of the property is possible in the buffer zones (JMC, 2021). An early warning system and a rapid response from management are vital in limiting the spread of invasive species. It is usually cheaper to establish an early detection system that finds and destroys invasive species before they become widespread, than to manage an invasive population after it has already established itself. Managers and their staff should be educated on the invasive species in their area and how to recognize them. Field staff should keep in mind to search for invasive species and report any findings so a rapid response can then be organised.

INDICATORS

Educated staff on invasive species in their area and appropriate actions to limit their spread.

A database of invasive species, their numbers, locations of spread and damage caused.

A prepared action plan for response to located invasive species.

5.10. Sustainable visitor management

WHY?

Poorly managed tourism or excessive visitor numbers at a site can pose major threats to OUV (Stolton et al., 2012). Visitor pressure is one of the main anthropogenic threats to the stability of our protected areas. Poor management can also degrade the quality of the visitor experience, while good management can provide an outstanding opportunity to increase the understanding of natural and cultural heritage and provide long-term financial support to site management, local communities and tourism providers (Stolton et al., 2012).

Appropriate visitor management is vital to improve positive aspects of forest management (safeguarding the OUV, protecting species, sustainable income…) and lessen the negative aspects of tourism and visits (site degradation, forest disturbances, damage to the OUV…).

It can also benefit transfer of knowledge and is a great vehicle for educating visitors on the importance of protected areas, World Heritage, and conservation.

HOW?

It is proved that legal restrictions are not as successful as visitor guidance by means of a proper and attractive trail system and awareness raising measures (JMC, 2021). Therefore, management should focus on establishing official hiking trails with attractive infrastructure, with an educational component, e.g. informational boards. Visitor infrastructure should not increase significantly (compared to the time of inscription), but it is possible to use the landscape conservation buffer subzone to construct visitor centres, trails, and even guest houses (JMC, 2021).

Existing infrastructure should be maintained and supplemented with information on WH.

Hiking off trails is allowed in the landscape conservation buffer subzone (JMC, 2021), but should be discouraged and visitors redirected to official trails.

Visitor pressure should be constantly monitored and visitors redirected from areas of vulnerability. Control in the field should be established by the area manager. If necessary, visitors violating the management regime should be fined or prosecuted.

Tourism and visitor management affects a variety of stakeholders in the landscape conservation zone, so any management actions should be developed in a participatory manner and include the opinions of all affected stakeholders (Leung et al., 2018).

INDICATORS

A visitor management plan is integrated into the forest management plan and provides plans for sustainable visitor management that ensures the protection of the forest ecosystem.

Visitor pressure is monitored and field control is established.

BOX B9: VISITOR MANAGEMENT GUIDES

Visitor management is a very broad topic that is difficult to explain fully in one criterion. There have been several authoritative guides on visitor management published by UNESCO and IUCN. We propose area managers wanting to delve into details of visitor management to consult the following documents. They are freely available online.

Managing Natural World Heritage, a World Heritage Resource Manual (2012). This manual from Stolton et al., published by UNESCO, encompasses all aspects of heritage management and also includes a chapter on tourism management. It is freely available on UNESCO's website, at URL: https://whc.unesco.org/en/managing-natural-world-heritage/

Tourism and visitor management in protected areas: Guidelines for sustainability (2018). This guide by IUCN outlines principles and guidelines for sustainable tourism management and provides many best practice examples from around the world. It is freely available on IUCN's website, at URL: https://portals.iucn.org/library/node/47918

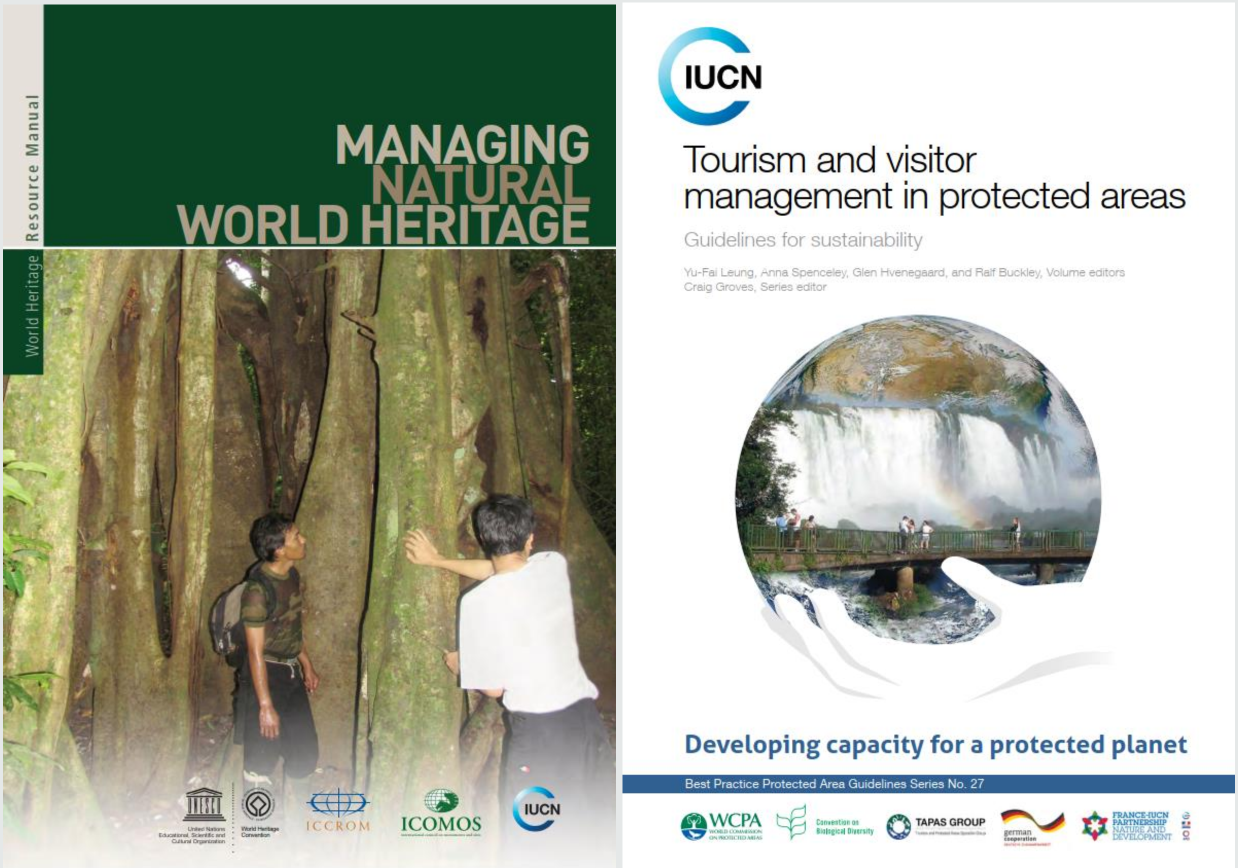

Figure 16: Publications by UNESCO and IUCN on tourism management (© UNESCO, IUCN).

6. Best practice examples

Silvicultural systems should be carefully selected in order to promote close-to-nature approaches and mimic natural processes in forest stands (femel system, plenter system). In Europe, there are several good examples, which present effective ecosystem-based management in beech forests. These examples are taken either from literature, from personal communication with forestry experts, or from the project's Workshop on Sustainable Forest Management Practices (D.T2.3.2).

Many good practical examples have already been included throughout the document, either in boxes or criteria, and are thus not repeated here. These include the German guidebook **Best Practice Handbook: Nature Conservation in Beech Forests Used for Timber** (Winter et al., 2020), and Slovenian legislation **Resolution on National Forest Programme** (2006) and **Rules on Forest Protection** (2016), among others.

The following chapters present a condensed overview of different best management practices.

6.1. Belgium: Sonian Forest

The Sonian forest is located at the southern edge of Brussels. It has a specific management history that has resulted in a very high density of old trees and forest stands, mainly beech. It covers an area of 4.421 ha and stretches over three Belgian regions, the Flemish, Brussels and Walloon. The management is divided between them, with 56 % of area being under Flemish management, 38 % under Brussels and 6 % under Walloon management.

Figure 17: Sonian Forest in Belgium (© Diego Michiels).

In the Brussels part of the forest (1.650 ha), almost 400 ha of forest stands are over 180 years old and some more than 230 years. These stands contain high densities of large trees (dbh > 80cm) and very large trees (dbh > 100cm), sometimes up to 20–30 trees per ha with standing volume around 600 m^3/ha. Over the whole inventoried area, more than 3.000 trees of > 3 m girth and more and about 7.000 trees of >250 cm girth were registered. This means that there are on average 6 big trees per ha present. About half of these trees occur in the old stands, and the rest are widely spread over the area as individual trees and old avenues. Current amount of deadwood in managed stands is low (< 10 m^3/ha). The whole area is registered as a Special Area of Conservation (Habitat directive) and Protected Landscape. The site is a hotspot for many species groups that are related to old beech forests, such as bats, mycorrhizal and saproxylic fungi, epiphytic mosses and lichens, saproxylic hoverflies, and beetles (e.g. *Stictoleptura scutellata, Gnorimus nobilis*). On average, there are 17 habitat trees per hectare which are often large oaks (dbh > 80cm) or large and very large beech trees. Those large oak trees are systematically considered as trees that will never be harvested for two reasons: oaks (*Q. petraea, Q. robur* and their hybrids) are considered as a rare species. The management plan aims to increase their ratio and by doing so to increase biodiversity and resilience of the old stands. On the other hand, those oaks are to be considered as potential seed trees.

In the framework of a new management plan, a functional network of habitat trees and set-aside patches was developed. This contains one of the large strict forest reserves (over 80 ha) and smaller strict set-aside areas (40 ha). Between them, there are 77 ha of "old growth islands" and a dense network of habitat trees comprising individuals and groups. For these trees, a dynamic approach is used: individual trees may still be cut (dangerous or exceptionally high value trees) but should be compensated by ingrowth from smaller size classes. The overall number should remain at least at the current level of 7.000, and the old growth islands should retain their "old-growth character", so no final cuts will be done there, only very selective fellings. When they eventually break down completely and lose their old-growth function, they can be reintegrated in the managed stand, but should be replaced by a new site. Selection of the islands and habitat trees is primarily based on their current occurrence, starting with selection of the remaining old stands. However, interconnection between set-aside areas and individual old habitat trees was also taken into account. The set-aside elements will be integrated in a matrix where a management of selective harvest and group fellings with habitat trees will be applied that will guarantee the required ingrowth of old trees, and should also lead to higher amounts of deadwood. Dead and dying trees remain in the set-aside patches, and also in the other stands, at least up to the threshold of approximately 10 m^3/ha.

The goal is to have multi-layered stands, with diverse species composition (management promotes 50 % beech and 50 % other species – *Quercus petraea, Carpinus betulus, Tilia cordata*). Logging favours beeches next to other trees, to achieve this diversity objective.

When felling big trees, only 16 meters of the log can be removed from the forest, the rest must remain there as deadwood, which represents 8 % of total wood volume.

6.2. Germany: Lübeck Forest

Lübeck forest is located near the city of Lübeck, a Hanseatic port northeast of Hamburg in northern Germany. In 1994, Lübeck's chief forester proposed a change in the way it was managed. Instead of the conventional method of logging with heavy machinery followed by replanting, a close-to-nature approach was introduced, developed in cooperation with scientists and nature conservationists. The city approved the change to "use wood and preserve the forest", the citizens endorsed the change by referendum, and the forest has been managed this way ever since (EFI, 2016).

The forest is around 5.000 ha in size and is composed mainly of beech and oak, mixed with ash, maple, hornbeam, elm, birch and alder, with some coniferous spruce, pine, larch and Douglas fir.

There are four goals in management of the forest. The first is to have a natural forest, which visitors can visit, enjoy, and learn from about natural functions of the forest and how a healthy forest can help sustain life on the planet. The second goal is to meet the commercial needs of the forest industry through sustainable management, while focusing on felling large trees on a needs basis, with buyers going into the forest to select the trees they want. The third goal is to contribute to the conservation of nature and enhancing biodiversity through the preservation of natural habitats. And the fourth goal is to be a store of carbon, contributing to efforts to slow the climate crisis.

Figure 18: Lübeck, itself a UNESCO Cultural World Heritage Site, is surrounded by a close-to-nature managed forest (© Pixabay / Achim Scholty).

There are no clear-cuts; no use of toxins or fertilizers; no drainage of wetlands; no surface clearing or slash-burning of brush piles; no work during ecologically sensitive seasons (spring and summer); no monocultures; no exotic tree species; no feeding of wildlife; no activities outside of the natural disturbance regime (all activities in managed forests mimic natural disturbance regimes in reference areas); and no use of large machines that would damage and compact the soil. Large trees are felled individually or in small groups of two or three. They are dragged out of the forest by horses, which have minimal impact on the soil, and brought to assembly areas where they are loaded onto trucks and taken to a local sawmill.

471 hectares are left entirely untouched to serve as reference areas for nature's ways; the goal is for the managed areas to look almost identical to the reference areas. Trees there are never planted, but are left to their natural processes. In doing so, they have learnt that trees germinated naturally grow better than sown or planted trees.

Habitat trees and dead trees are protected for birds, bats, insects, fungi and other life forms.

On good beech tree sites, where trees are competing, thinning is done two or three times until the trees reach 40 cm diameter at breast height, after which no further thinning is needed to improve the quality of the beeches. The target diameters for commercial felling are 45 cm for spruce, 50 cm for pine, 75 cm for beech and 80 cm for oak.

Lübeck's goal is to deliberately not maximize the forest yield; they want to balance social, ecological and economic needs, while growing the forest as a whole. In the timber-managed area of 4.670 hectares, in 1996 the forest held 315 cubic metres of timber per hectare (m^3/ha). By 2004 this had increased to 340 m^3/ha and by 2018 to 429 m^3/ha. In 1994 the annual incremental growth was 8-10 m^3/ha; now it is 10-12 m^3/ha. Their goal is to reach a total forest inventory of 600 to 800 m^3/ha, both as a store of carbon and as the forest recovers its old-growth characteristics.

In 2016 they cut 14.500 m^3 at a rate of 3,2 m^3/ha, including 800 m^3 of high-quality oak, which sells for around 430 euros per cubic metre. They also provided 2.500 cubic metres of timber for firewood and other wood products. On average, the trees felled are 10-20 cm wider than those felled in conventional forests. The older a beech tree, the firmer its wood, and the more it sells for. Their rule of thumb is that wood from deciduous trees should sell for three times the harvesting cost, while coniferous wood should sell for 1,5 times. Of the 14.500 cubic metres felled, 3.500 m^3 was left in the forest for soil improvement and as dead wood, and 11.000 m^3 were sold:

- 3.500 m^3 high-quality deciduous: 75 % value-added products, 25 % firewood
- 1.000 m^3 low-quality deciduous: 20 % value-added products, 70 % building timber, 15 % firewood
- 6.500 m^3 coniferous: 20 % value-added products, 65 % building timber, 10 % pulp

By following their close-to-nature methods their costs have been reduced drastically, and their timber, since it has been certified by the Forest Stewardship Council, sells for a premium. On average, the sale of timber generates €1,9 million a year.

6.3. Slovenian Forestry School

With 58 % of forests, Slovenia has one of the highest percentages of forest cover in Europe (SFS, 2021). Slovenia's close-to-nature forestry tradition spans back to the 19th century. Professional work in all forests, regardless of ownership, is ensured by a unified public forest service (Slovenia Forest Service), that manages planning of all forests. Management is based on constant planning, implementation and monitoring. Research guides decision making, with forest reserves serving as reference areas. Data on forests is publicly available. Silviculture methods used are possible due to a good network of forest roads with their own information system (Čater and Diaci, 2020a).

Forest regions are divided into a total of 231 forest management units for which individual forest management plans are produced. Each FMU (around 5.000 ha) has one or more foresters assigned to it, responsible for tree selection, tending, silvicultural measure, protective measures, maintaining skidding tracks and forest roads, and any other forestry intervention. FMPs describe forest state and development trends, analyse the past development of stands, the effects of realised forest measures, and set future management goals, together with guidelines and measures for implementation of desired goals. These are related to important forest functions (ecological, social, and productive) for which a map of forest functions is made and is regularly updated. Up to 10 % of plans are updated or renewed each year in Slovenia (for around 100.000 ha of forest). All activities that take place in the forests are based on these plans. Up to 95 % of forests are regenerated naturally.

There are three principles the Slovenian forestry school is focused around: **sustainability, close-to-nature approach, multi-functionality of forests** (see chapter **3 Multi-functionality of forests**).

There are three main silviculture methods used by Slovenian forestry school to ensure continuous forest cover, naturalness and multi-functionality of forests.

The group selection system is the most widely used. This silviculture method involves final felling of small groups of trees. The resulting openings permit more sunlight to reach the forest floor than with individual tree selection, and some regeneration of shade intolerant species is possible. Planned repeated application of group fellings results in small groups or clumps dispersed through a stand, with each group containing trees of similar age and size classes. We refer to group selection whenever the intervention area is smaller than 0,5 ha (JMC, 2021).

Individual selection system is also used. This silviculture system involves removing individual selected trees from specific size or age classes over an entire stand area. Removing single trees creates small openings so this method favours the regeneration of species that can tolerate shade. Individual tree selection is used to create or maintain an uneven-aged stand, reflecting a predefined (semi-)natural age or size distribution. It involves periodic selective harvests (final harvest and thinning combined), and no rotation period and continuous regeneration (JMC, 2021).

Free silviculture method is the third method and combines principles of the individual selection, group selection and irregular shelterwood systems. It is characterized by the free choice of silviculture measures but requires a lot of professional competence and consistency. It is suitable for all types of sites and stands, but most of all in cases where we can not only consider the principles of group selection or individual selection alone: it may be applied on degraded and changed stands, where there are problems associated with inappropriate former management or in degraded or declining forests. The principles of the free silviculture technique combine the preservation of natural site fertility, nursing of young forests and tending of the adult stand, preserving individuality, attention being paid to function holders, natural regeneration, and great alignment with natural processes. Measures should mimic natural conditions and cause as little disturbance to the forest as possible. Direct or indirect tending should provide protection against adverse conditions and enable the selection of quality individuals and promote their desired positive properties (Čater and Diaci, 2020b).

A vital part of Slovenian forestry school is also its **integration of nature and biodiversity conservation**. This is realised by common forestry and hunting planning. Biodiversity conservation is integrated into forest management while wildlife management is prepared in hunting plans.

The management of forest Natura 2000 sites is based on the preparation and integration of nature protection guidelines (NPG) in the Forest Management Plans (FMPs). Every year, the Institute of the Republic of Slovenia for Nature Conservation (IRSNC) reviews all available data on species and habitat types, reviews individual objectives and combines them into the corresponding management zones. The prepared NPGs are submitted to Slovenia Forest Service (SFS). SFS reviews the NPGs and data on the state of the forest from the latest inventories of sample plots and stands. SFS prepares a proposal for the FMP and also submits it for review to IRSNC (Danev el at., 2020). The expected result is an integrated plan with forestry and conservation goals, and measures to achieve them.

Wildlife management is integrated in hunting plans, also prepared by SFS. Ungulate management is important in ensuring an over-abundance of animals does not cause over-grazing and threatens forests' ability to naturally regenerate. A big part of wildlife management in Slovenia is also large carnivore (bear, wolf, lynx) management, which is authorized by the Ministry for Environment and Spatial Planning and performed by SFS. Management actions are proposed by SFS, based on field data, and approved by the Ministry. Finding a balance between conserving protected species and assuring coexistence with humans is key to effective management. Integrative approaches that take into account all relevant stakeholders are a key measure (Stergar and Poljanec, 2020).

A vital part for ensuring integrative approaches are effective is constant monitoring, gathering data, and adapting management decisions based on new information. This adaptive approach is used both for forestry (control method, see **Box A1**) and biodiversity conservation and wildlife management.

6.4. TRIAD System

The TRIAD system was first proposed by Seymour and Hunter (1992) as a means of achieving various management objectives while reducing land-use conflicts. It is advocated as an effective strategy to minimise conflict among various users while achieving varied forest management objectives on different parts of the land. It is a combination of the traditional concepts of land use, i.e. “land sharing” and “land sparing” (Messier et al., 2020) (Figure 19).

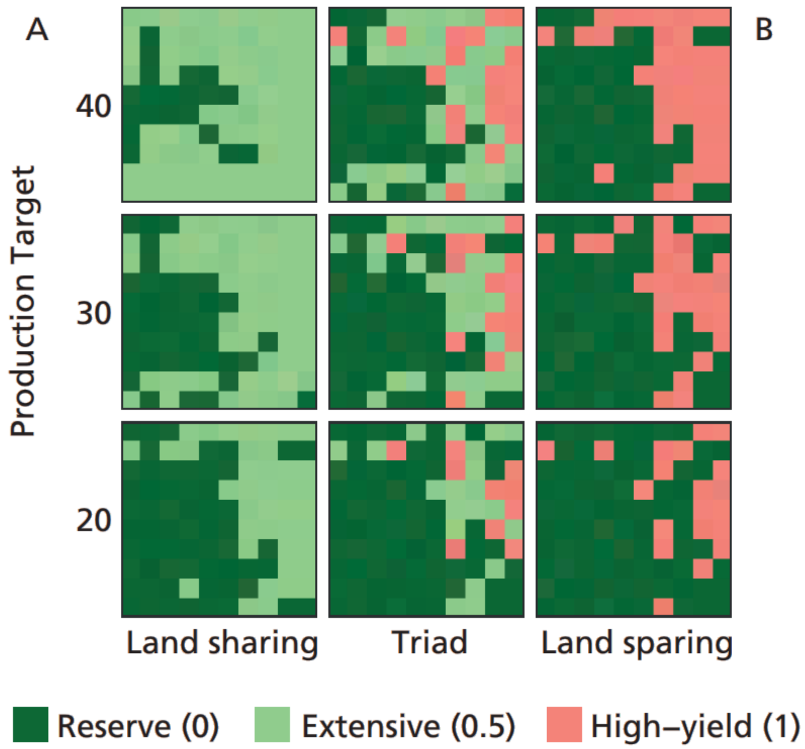

Figure 19: Conceptual model of a forest landscape under various management approaches and production targets. Maps in the same row produce the same quantity of wood, but use different proportions of unmanaged/protected, extensive and high-yield forestry to provide the production target (© Messier et al., 2020).

It divides a forest area into three zones with different management objectives. First, there is a conservation zone with the main objective of protecting biodiversity. Forest harvesting here is forbidden or reduced to a minimum. Usually this zone corresponds to established reserve areas. Second, there is a multi-use or extensive management zone where timber harvesting occurs at a level that minimises impacts on biodiversity and other ecosystem functions. This zone corresponds to areas under close-to-nature forestry. Third, there is a zone, where lack of wood production in the first zone is compensated with intensive wood production. This corresponds to monoculture plantations. The TRIAD system works ideally when the location and extent of each zone is carefully planned and managed by a single authority. Proportions of each of these zones depends on the context of the area where the system is to be implemented (Messier et al., 2020).

High production zones should be located on productive, accessible land with relatively low conservation value, away from protected areas. The faster the timber can be produced in a high yield zone, the bigger the first zone with protected reserves can be. By transforming a small area from close-to-nature forestry to high-yield stands, we can greatly increase the area of forest reserves and help biodiversity, without losing on timber production (Messier et al., 2020).

The TRIAD system offers an alternative to strictly integrative forest management (i.e. close-to-nature forestry), which alone lacks the ability to preserve large swathes of old-growth habitat alongside an economically viable level of wood production (Nagel, 2017). Close-to-nature forestry should still form the basis of the TRIAD system, but including a certain proportion of high-yield areas into the forest matrix means the proportion of forest reserves can be increased from the currently inadequate European average of < 1 % of total forest area.

6.5. Ten recommendations for forest restructuring and an ecosystem-based transformation of forest management

Ten recommendations for forest restructuring and an ecosystem-based transformation of forest management are adopted after Ibisch and Blumröder (2018) and are based on forest ecosystems in Germany.

1. The conversion of the extensive coniferous monocultures must become obligatory for all types of property, at least on an appropriate part of forest stands.
2. Consideration should be given to new models for the spatial design of commercial forests.
3. Additional weakening of forest ecosystems by infrastructure must be avoided urgently, especially if this leads to fragmentation and opening of closed forest stands.
4. In future, research and practice should focus more on how silvicultural measures can strengthen the self-regulating forces of the forest, e.g. by promoting microclimatic regulation, cooling and buffering capacity.
5. All forestry practices must be put to the test and questioned with regard to the impairment of forest ecosystems and adaptation to climate change.
6. The remaining old mixed deciduous forest shall be adequately protected.
7. Forests must be given more room for natural forest development.
8. Opportunities for the restructuring of forests must be exploited, especially after catastrophic events.
9. Modern wildlife management must replace traditional hunting practices that are demonstrably not conducive to forest restructuring.
10. For the forest, the concept of holistic ecosystem management should be followed instead of a one-sided, business-oriented forestry that opposes the requirements resulting from ecology. Rather, forest management, wildlife management, the promotion of the landscape water balance and nature conservation should be considered together.

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8. Annexes

8.1. Important documents and further reading

- **Ancient and Primeval Beech Forests of the Carpathians and Other Regions of Europe - State of conservation reports, mission reports, management plans, decision, maps, advisory bodies evaluations, nominations,**

  https://whc.unesco.org/en/list/1133/documents/ (accessed 1. 7. 2021)

- **The 2030 Agenda for Sustainable Development,**

  https://sdgs.un.org/2030agenda (accessed 12.7.2021)

- **Convention on Biological Diversity,**

  https://www.cbd.int/ (accessed 21. 7. 2021)

- **EU Biodiversity Strategy for 2030,**

  https://ec.europa.eu/environment/strategy/biodiversity-strategy-2030_en (accessed 12.7.2021)

- **State of Europe's forests 2020,**

  https://foresteurope.org/wp-content/uploads/2016/08/SoEF_2020.pdf (accessed 28.6.2021)

- **Guidance Document on Buffer Zone Management and Buffer Zone Zonation**

8.2. Criteria and indicators checklist

Criterion 1: Maintenance of a natural forest structure	
Indicators	Total forest area (ha)
Heterogeneous uneven-aged forest stands	
Forest cover maintained or increased	
Criterion 2: Promotion of natural regeneration	
Indicators	Percent of total (%)
Percentage of tree regeneration that is natural	
Criterion 3: Avoidance of non-native tree species	
Indicators	Yes / No
Plan forbids the promotion of non-native tree species	
Strategy to restructure existing non-native stands	
Criterion 4: Optimising growing stock	
Indicators	Volume (m^3/ha)
Growing stock optimised according to site conditions	
Criterion 5: Maintenance of diverse forest edges	
Indicators	Yes / No
Forest edge is structurally diverse	
Criterion 6: Maintenance of farmland wooded elements	
Indicators	Yes / No
A diverse structure of open country in the landscape buffer subzone	
Criterion 7: Conservation of biodiversity	
Criterion 7.1: Deadwood volume	
Indicators	Yes / No
30 m^3/ha or 10 % of deadwood volume	
Presence of site-specific indicator species	
Criterion 7.2: Quiet zones	
Indicators	Yes / No
Mapped locations of important areas for protected species	
Quiet zones established and human activity limited	
Criterion 7.3: Habitat connectivity	
Indicators	Percent of buffer zone (%)
Matrix of old-growth patches	

Forest cover in the buffer zone	
Number of habitat trees	Total number (n/ha)
Criterion 7.4: Terricole structures	
Indicators	Yes / No
Management plan contains guideline to preserve terricole structures	
Criterion 8: Protection of intangible benefits	
Criterion 8.1: Soil and water protection	
Indicators	Yes / No
Logging/harvesting techniques that limit soil damage	
Water source protection through legislation	
Criterion 8.2: Avoidance of biocides and fertilisers	
Indicators	Yes / No
Management plan forbids the use of biocides and fertilisers.	
Stakeholders aware of limitations and reasons for them.	
Criterion 9: Species management	
Criterion 9.1: Hunting	
Indicators	Yes / No
Monitoring of wildlife and game impact	
Harmonized herbivore game populations	
Criterion 9.2: Invasive species management	
Indicators	Yes / No
Educated staff on dangers of invasive species	
Prepared database and action plan on invasive species	
Criterion 10: Sustainable visitor management	
Indicators	Yes / No
Visitor management integrated into management plan	
Visitor monitoring established	