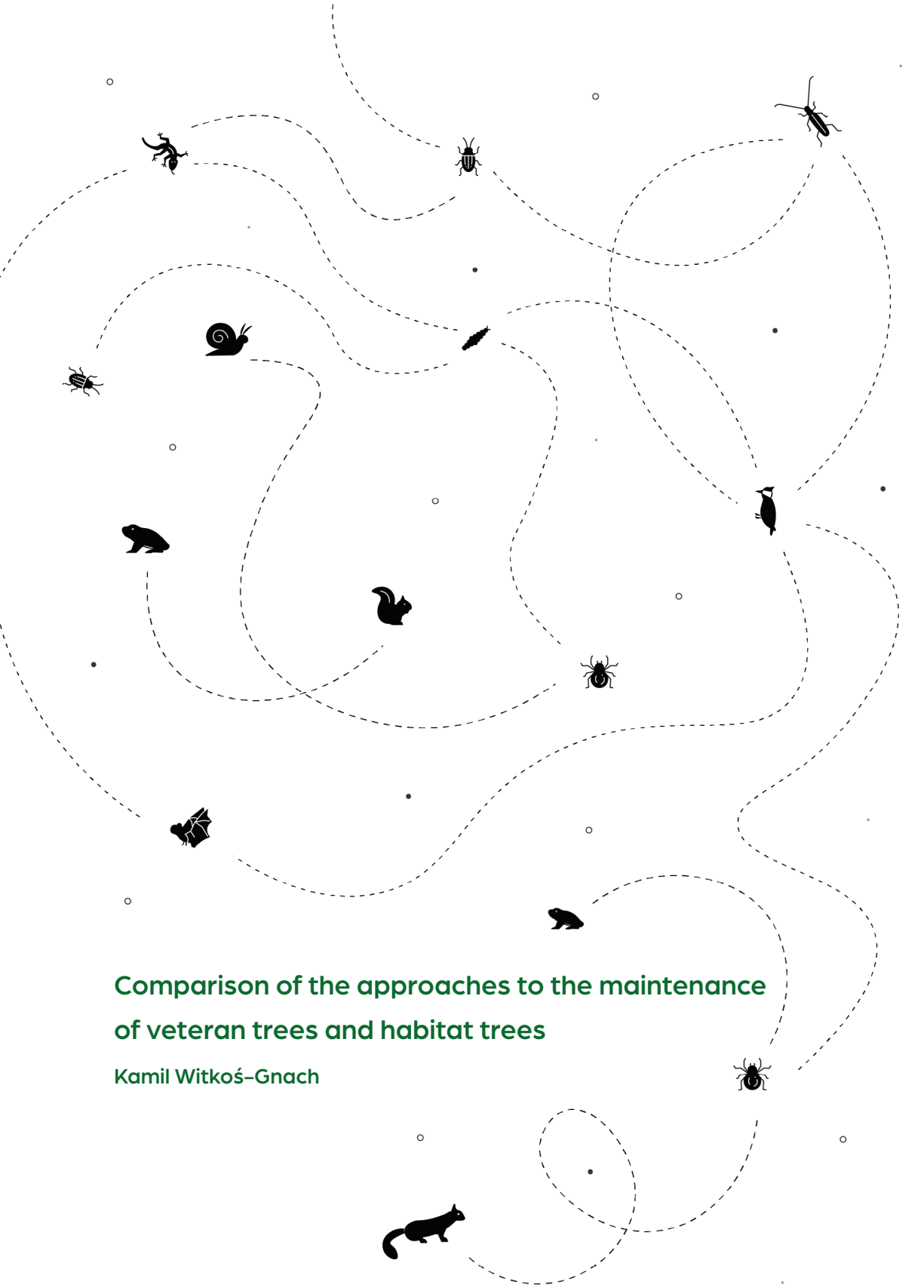
Kamil Witkoś–Gnach

Comparison of the approaches to the maintenance of veteran trees and habitat trees



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Fundacja EkoRozwoju, Wrocław

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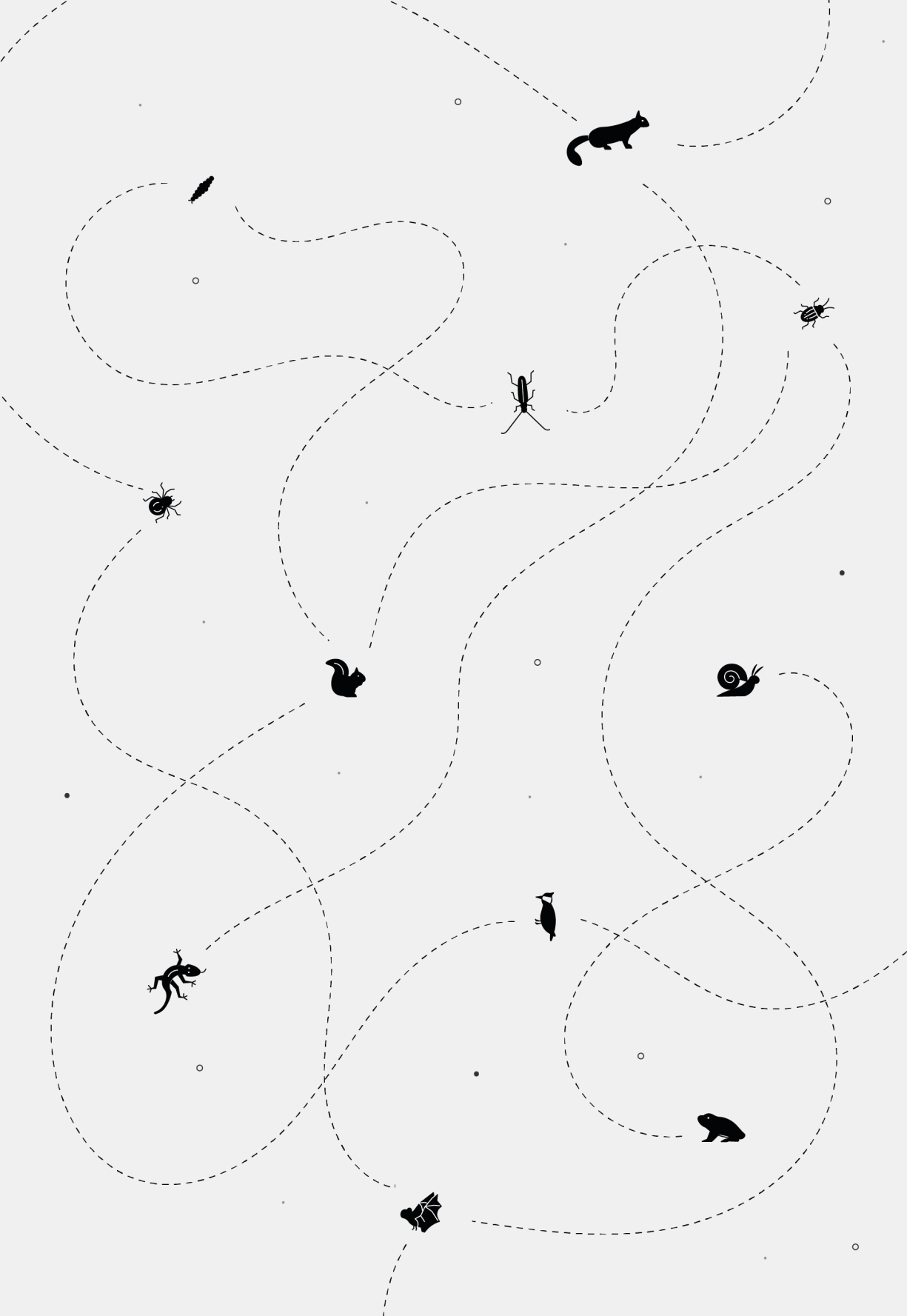


1. Background

LIFE Osmoderma 2017 project

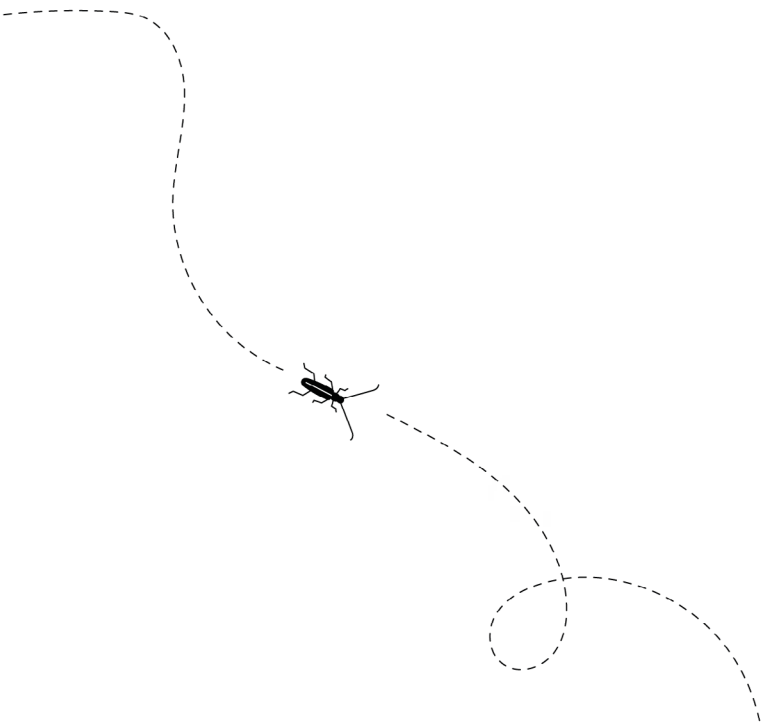
The Natura 2000 site 'Poodří' (SCI) in the Czech Republic is the most important site for the hermit beetle *(Osmoderma eremita)*, a priority species for conservation under the Habitats Directive. Located in the Moravskoslezský region, and in the area of Moravská Brána (Moravian Gate), this is an important migration corridor between the Pannonian and Continental biogeographical regions. However, the current conservation status of the hermit beetle population in the SCI, as all across Europe, is 'unfavourable' because of the loss and fragmentation of habitat and the isolation of micro-populations. In the project site, the species mostly lives in old pollarded willows, though sometimes in other tree species. The willows have not been managed for many years and so only very old trees remain suitable for the species. Without restoration of the traditional pollarding management, the habitat of the hermit beetle will soon disappear.

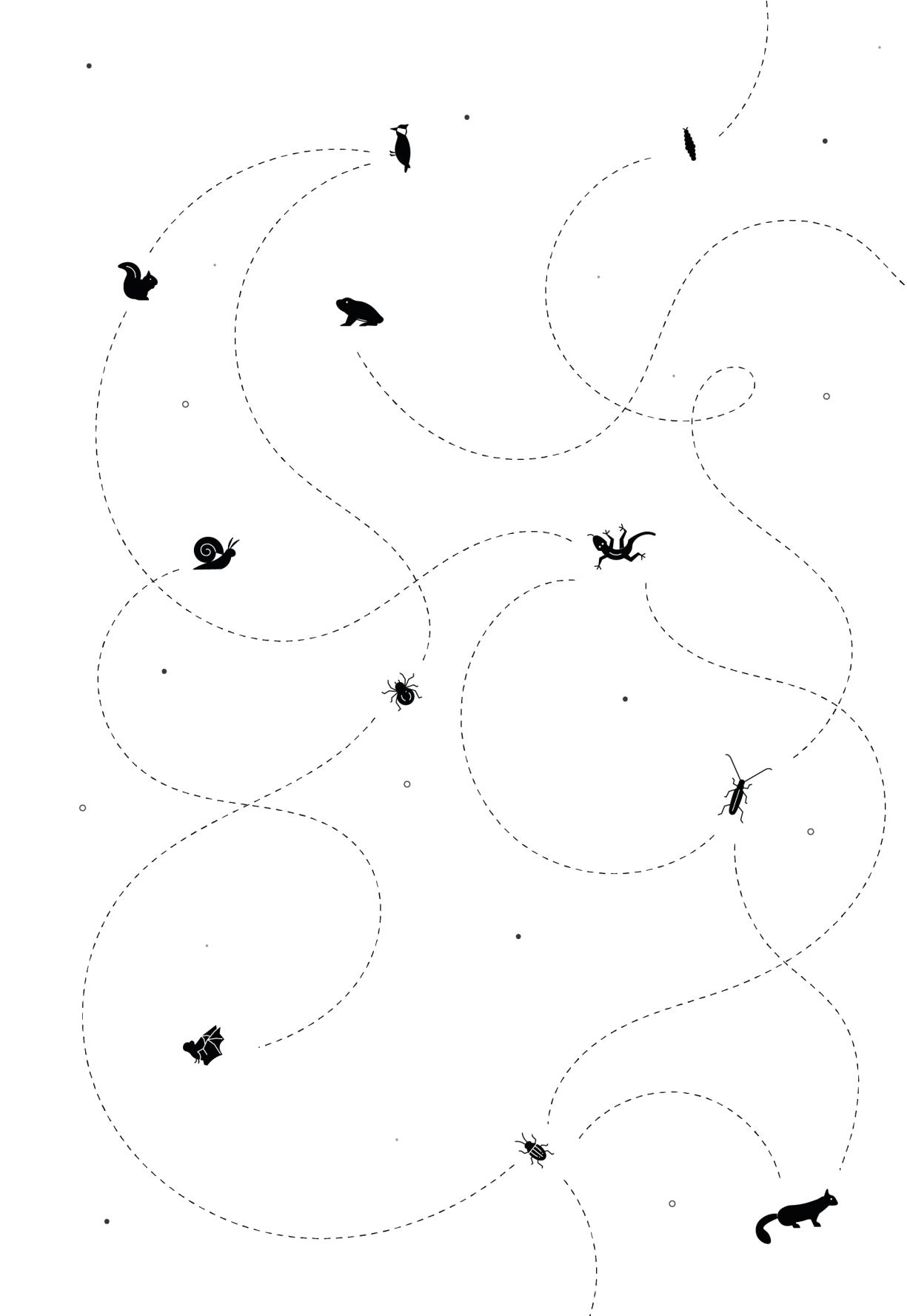
The main objective of the LIFE Osmoderma 2017 project is to improve the conservation status of hermit beetle *(Osmoderma eremita)* in the Natura 2000 site 'Poodří'.

Interest in old trees in Europe is growing, which is reflected in an increasing number of civic initiatives for their protection, frequent media coverage, and publications. In Poland, a unified database of monumental trees is available. The Central Register of Nature Protection Forms (www.crfop.gdos.gov.pl) contains over 32 000 nature monuments, including monumental trees. In addition, many portals and blogs are run by tree enthusiasts who collect information about old trees. The observations suggest that there are many more mature trees than formal monumental trees, and they deserve monitoring and individual protection. In the UK, where the monitoring of ancient trees has been going on for years, the Ancient Tree Hunt database contains now over 120 000 entries. The situation is probably similar in other countries. Veteran, monumental, and habitat trees require special care and they should not be treated in the same way as other mature or young trees. To understand them better, let's look at the stages in a tree's life leading up to old age.

Ancient trees play a crucial role in Europe's cultural landscape due to their rarity and importance as a habitat for many organisms. Playing a vital role in the landscape, they provide unique habitat for thousands of species over their lifetime, including many protected species – they are the nodal points of the ecosystem. Their loss always means a loss for the biocenosis in which they occur.

Ancient trees are rare compared to other age classes. They are the few survivors, and single ones only boast an age of thousands of years. Those who survive may have the longevity genes, yet another argument for their protection. Old trees are a natural resource that cannot be restored on a human scale: we need another 400 years to restore a 400-year-old oak tree. And not many trees from the current young generation will have the chance to live to old age in the future. Which of them will have the right genes, favourable habitat conditions, and not be killed by disease, catastrophe, or man?





2. What are habitat / veteran trees

With the development of tree-related industries such as nature conservation, urban forestry, or arboriculture comes a better understanding of tree management's complexity and functioning. Depending on their characteristics, trees may be named differently. The terms commonly and often interchangeably describe trees include monumental, veteran, ancient, historic, old, and large.

The abundance of terms might be challenging. One of them is the problem with recognising valuable trees by owners and practitioners. Another is related to communication – we need more precise definitions to communicate between different parties involved in tree management. Below is a summary of definitions that are in general use.

Monumental tree/green monument
This term is most commonly referred to as legal protection of trees in many countries. Most commonly within this framework, trees are included in this category based on trunk girth. Therefore it is a legally operational term that directly relates to their assessment and care. This term is based on the International Union for Conservation of Nature (IUCN) classification, which is a membership Union composed of both government and civil society organisations.

Big/old tree
There are many key terms commonly used in scientific literature to describe a group of trees with habitat potential. A literature review revealed that the most frequently used terms are „big" and „old". These general terms might prove challenging when it comes to the comparison of different papers and research. Often these do not include an explanation of what they mean by old.

Veteran tree

Over the last decade, the number of guidance that used the terms „veteran" and/or „ancient" grew very quickly. These appear to be the most commonly used terms in modern arboriculture.

According to Woodland Trust definition, unlike an ancient tree, a veteran tree can be of any age, but it is a tree which shows ancient characteristics. These may not just be due to age but could result from damage or management. Ancient trees are all veterans, but not all veterans are ancient. A veteran tree will have some of the features found on an ancient tree but does not need to have a great age. Although they're not as old as ancient trees, they're still incredibly important.

Another proposal for a definition of veteran tree was proposed in the scope of the international VETCert project, a broad definition which includes the following characteristics:

- great chronological age for their species;
- in an advanced life stage where they may show retrenchment and have been through phases where they have demonstrated resilience;
- often large for their species;
- showing a complex structure or architecture with hollowing, decay, roots inside the trunk, a colony-tree structure/multiple functional units being common features;
- have high biological/ecological values;
- have a high cultural or heritage value – but this alone does not make a tree a veteran (for example a recently planted tree by a famous person is not a veteran).

Ancient tree

Ancient trees are those which have reached a great age in comparison with others of the same species.

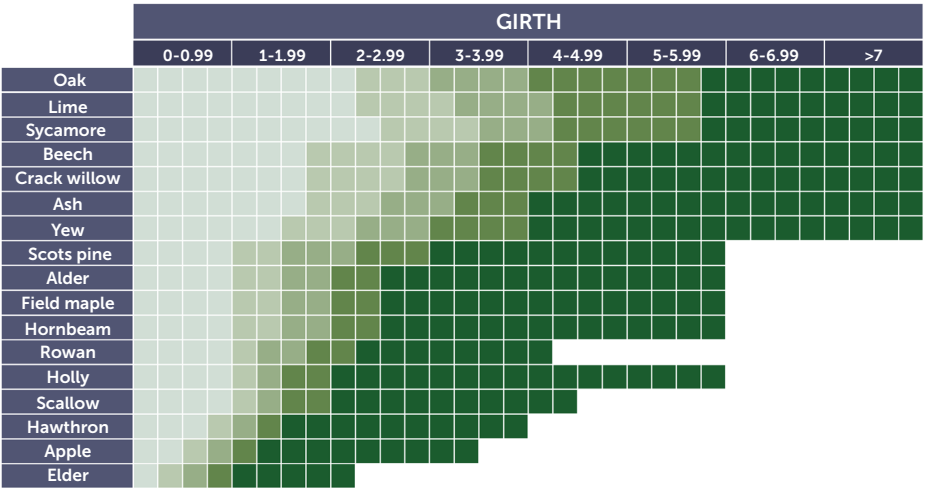
The exact age at which you'd call a tree ancient depends on the species of tree and other factors including the type of site where it's growing. It is often difficult to estimate how old an ancient tree is, but one method that is used, alongside considering the ancient characteristics, is to measure the girth of the trunk (see further information below). The features which can be found in an ancient tree:

- crown that is reduced in size and height;
- large girth in comparison to other trees of the same species;
- hollow trunk which may have one or more openings to the outside;
- stag-headed appearance (look for dead, bare, antler-like branches in the crown);
- fruit bodies of heart-rot fungi growing on the trunk;
- cavities on trunk and branches, running sap or pools of water forming in hollows;
- rougher or more creviced bark;
- an 'old' look with lots of character;
- aerial roots growing down into the decaying trunk.

Ancient vs veteran

Veteran is a term describing a tree with habitat features such as wounds or decay. The terms ancient and veteran have been used interchangeably in the past, however, it is important to know the differences between them. A veteran tree is a survivor that has developed some of the features found on an ancient tree, not necessarily as a consequence of time, but of its life or environment. Ancient veterans are ancient trees, not all veterans are old enough to be ancient. A veteran may be a young tree with a relatively small girth in contrast to an ancient tree, but bearing the 'scars' of age such as decay in the trunk, branches or roots, fungal fruiting bodies, or dead wood. These veteran features will still provide wildlife habitat.

Fig. 1. Chart of tree size in relation to age and development phase (adapted from Ancient Tree Forum Draft Girth Chart for Consultation, August 2021)



Legend

life stage	likelihood of specified veteran characteristics of decay-dependent species being present
ancient	very likely
mature	likely: if present, the tree is veteran
mature	possible: if present, the tree is veteran
early mature	relatively unlikely: if present, the tree is veteran
young	not a veteran tree but may have veteran characteristics or decay-dependent species and if present, the tree may have special habitat value

Habitat tree

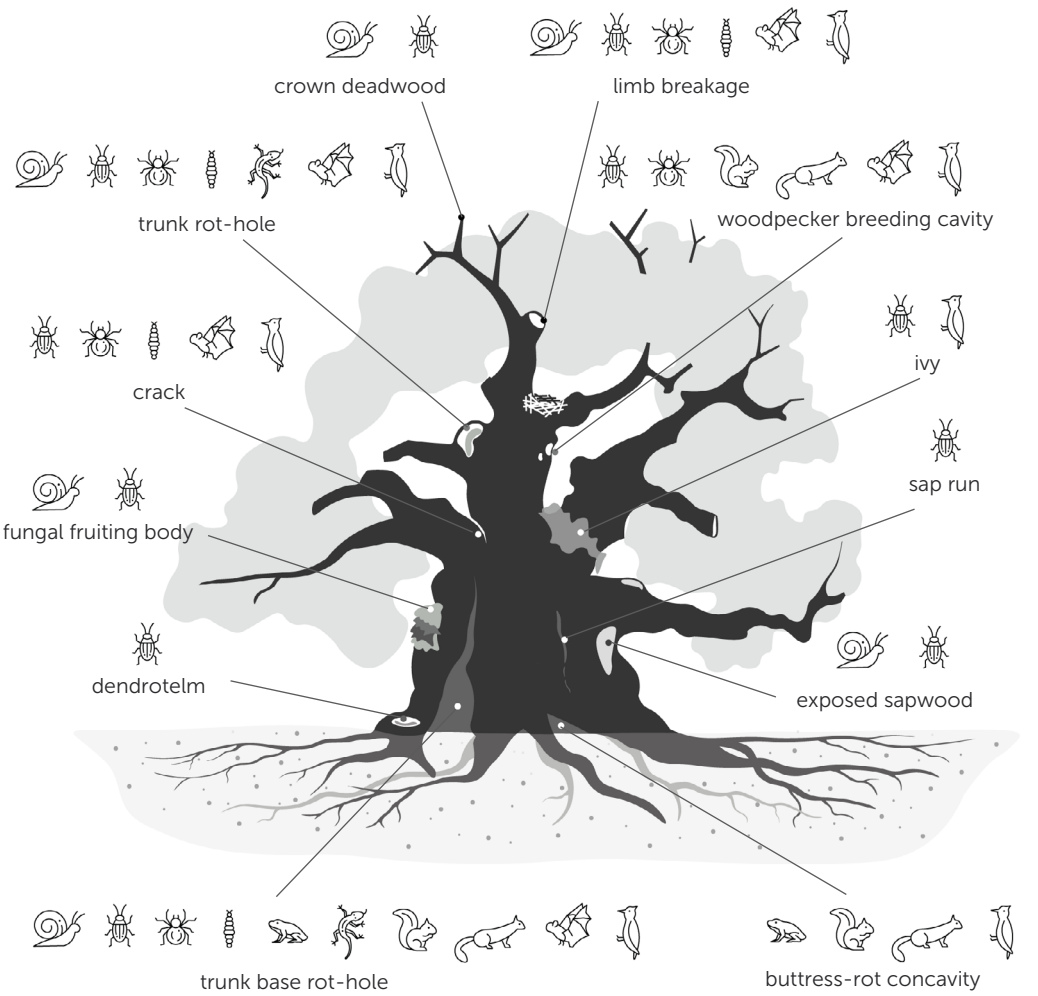
Habitat trees are standing live or dead trees providing microhabitats such as hollows, cavities, wood decay, deadwood, etc. Habitat trees and the associated microhabitats are crucial for biodiversity as they host many valuable species. In addition, a substantial number of species depend on or benefit from non-living wood and habitat trees.

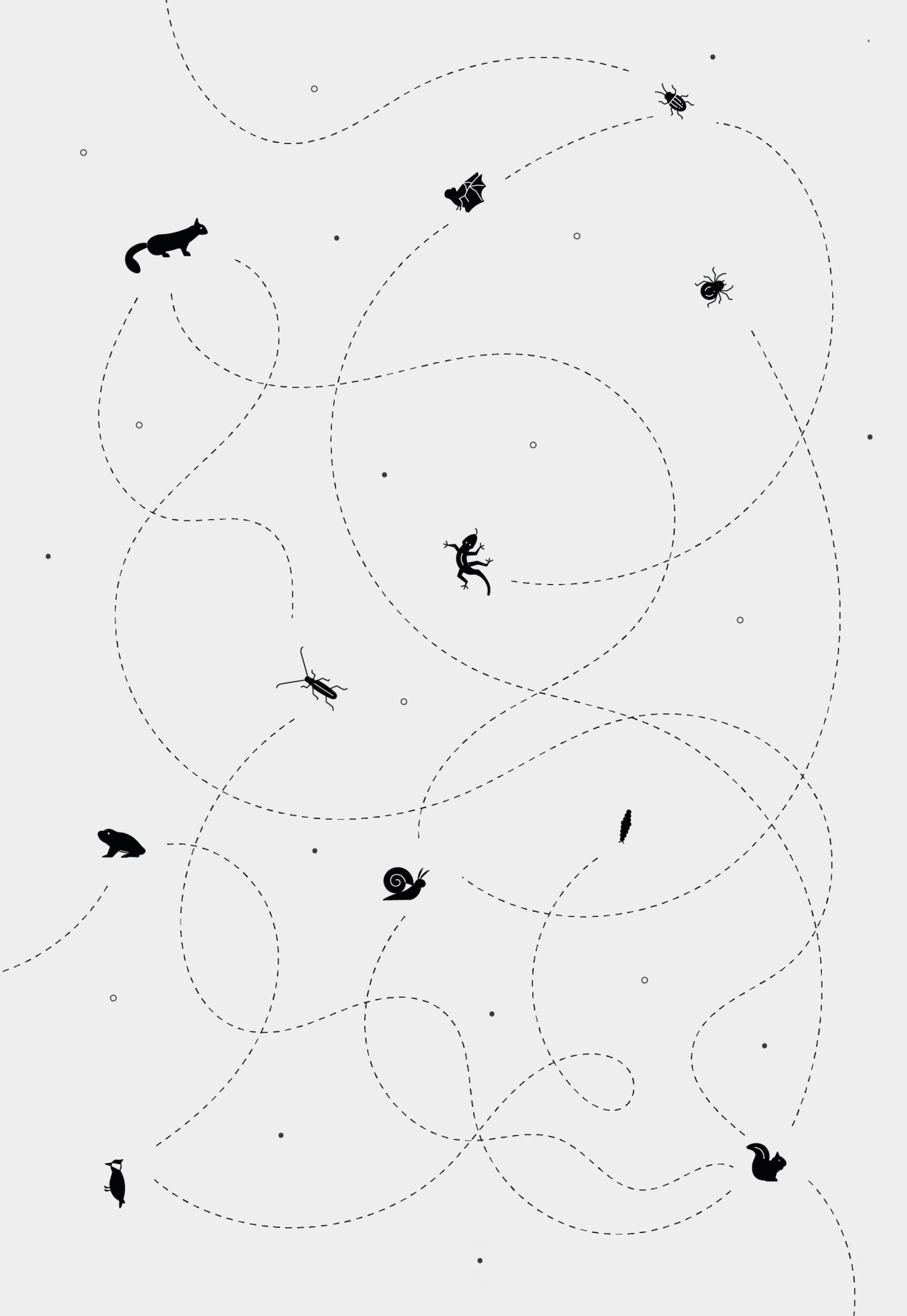
The abundance and diversity of microhabitats strongly increase with trunk diameter and, therefore, typically, with tree age (Bütler and Lachat 2009; Vuidot et al. 2011, Larrieu and Cabanettes 2012). The ecological value of a tree, therefore, increases with its age. For these reasons, particular attention is being given to veteran trees, and they are currently being inventoried in several countries to promote their preservation.

In Europe, veteran trees may be found in three different types of ecosystems: relicts of orchards or traditionally managed forest zones (coppices with standards, wooded pastures), old-growth forests, or parks. It should be concluded that ancient and other veteran trees are at the same time habitat trees. In Czech Republic, the definition of a tree of exceptional value is defined as senescent is set within the country standard (SPPK A02 009) and operates on a point system. A minimum of 7 points needs to be reached from the following factors (trees cannot qualify on size alone):

- Great size (DBH) (4)
- Condition (a significantly poorer condition in one of the key aspects defined by standard (SPPK A01 001) (5)
- Tree with extensive central cavities or with massive damage (1)
- Growth shape (uniqueness) (1)
- Evidence of protected species (1)
- Heritage tree in law (1)

Fig. 2. A range of example microhabitats associated with veteran trees. These include hollows, rot, cracks, sap runs, fungal fruiting bodies, exposed wood and many others. These microhabitats are used be a range of species from bats and birds through insects and other invertebrates, mammals, fungi and many other plants and animals.



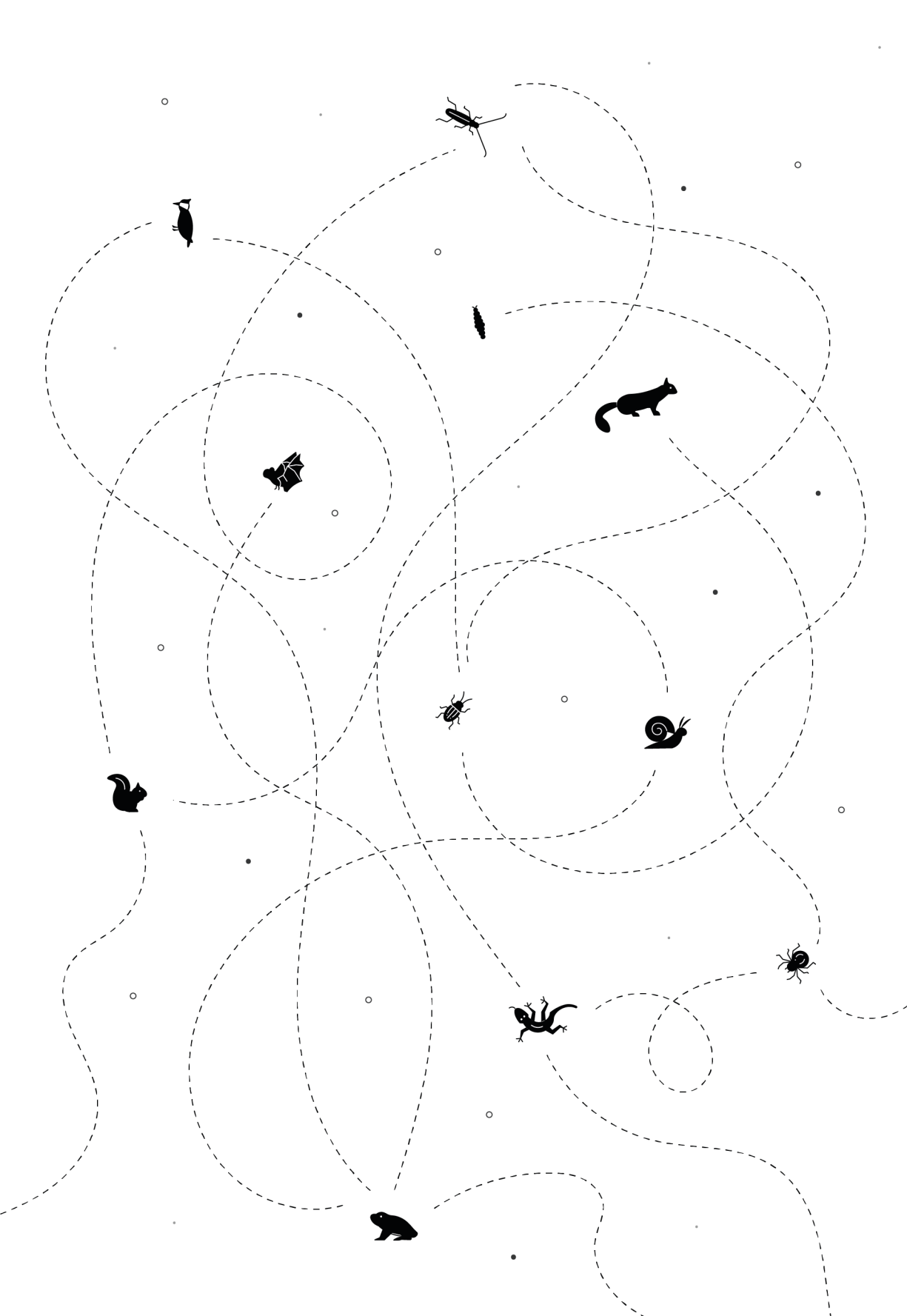


3. A tree-related microhabitats – key feature

As indicated above in the comparison of definitions, the key feature that is decisive for a tree to be a veteran or habitat tree and is naturally part of the ancient tree life stage is the presence of tree-related microhabitat.

This is a feature present on a tree, which is used by other species during at least a part of their life cycle. They can be used for breeding, feeding and sheltering. Each tree-related microhabitat provides very specific conditions depending on its characteristics: size, shape, position in the tree, sun exposure, humidity, etc. Species differ with their preferences to a specific type of microhabitat. The more diversified the microhabitats, the greater the number of species that can find the right conditions. It's important to note that these microhabitats are characterised by limited life span so for many species the more often the same type of microhabitat occurs the easier it is to colonise a new one when the previous disappears.

Many of the tree-related microhabitats are at the same time diagnostic features in tree assessment. **A diagnostic feature** is a feature on or around a tree that is indicative of tree structure, damage, wood decay or habitat condition and provides important information about the condition of the tree. Diagnostic feature is a relatively new term in the context of tree assessment. The term was coined to distinguish between tree characteristics and wood defects, a term used in forestry. This is due to the fact that many wood defects are natural characteristics of trees that affect the suitability of the wood for economic use, but may not affect the condition or stability of the tree or part of it. Some so-called „defects" in wood may even increase stability, such as stem toe or reaction wood.



4. Review of arboricultural standards

In recent years, many documents called "standards" have appeared across Europe, so it is worth recalling the definition of this type of document. A standard is a special type of publication that defines requirements, specifications and procedures, the application of which ensures that products, procedures or services are optimised for the purpose for which they are used. In short, a standard answers the fundamental question: "What is the best way to perform a task?". A standard is accepted by various industries, institutions and people, and describes a manner of performing a given task which is considered appropriate at the time of adoption and implementation of the standard.

A special feature of standards is that they define a given task "here and now", as opposed to strategies or local policies that indicate a vision to be pursued or goals to be achieved within a specific period of time (for example, standards for planting trees specify what the seedling should look like and how the tree should be planted, but they do not specify the number of trees planted in a given city – this is the task of a strategy or other land development plan). The standard is universal for a given activity or process and is not limited by local specificity. The process of standardisation began many centuries ago with weights and measures, and nowadays, especially in the 20th century, it has extended to other areas. "Arboricultural" standards developed in the 1990s in the United States, and they were followed in Western Europe some years later. Currently, the process of standardisation of working in trees is carried out in many European countries, including the Czech Republic, Poland, Germany and Great Britain.

This process was usually associated with a greater appreciation of the role of urban trees and wooded areas, and recognition that taking proper care of them is essential for their long-term and safe growth. In the case of trees, standards can address technical issues related to work performed in them, the management of tree data or education of tree carers. In most cases, the need for standards resulted from the fact that more and more people dealt with trees and mutual understanding between parties involved in this process was essential. Regulations concerning trees usually describe very basic aspects, whereas taking care of trees is connected with various fields

and functions on many levels. Legal aspects related to public safety were also an important issue.

One of the main motivational aspects in developing the Standards described in this document is that trees are one of the most valuable and durable components of green infrastructure. However, their value is all too often under-appreciated, and they undergo treatments that deteriorate the prospect of their optimal functioning. Another motivational aspect concerned the growing need for better communication between numerous entities dealing with trees. Trees are special organisms living in the vicinity of people, in the management of which are involved, among others, local governments, road authorities, nature conservation authorities, private owners, housing co-operatives, designers, landscape architects, urban planners, tree inspectors, contractors performing work in trees and green areas, scientists, non-governmental organisations and many others. Such a large variety of involved institutions and people requires a harmonised understanding of processes and work related to tree management. The standards described in this document constitute a set of guidelines, procedures and techniques used in work involving trees or their immediate surroundings important to them. They concern the performance of work that meets the needs of people or ensures public safety, but according to the rules of conservation arboriculture, this work also has to maintain tree integrity and welfare, so that the needs of people and trees as well as living organisms associated with them are balanced.

Table 1. Comparison of consulting standards

COUNTRY Title of standards	**CZ** Special tree treatment	**SE** Standards for Conducting Tree Inventories in Urban Environments	**DE** Baumkontrolle richtlinien	**PL** Tree assessment standard	**CZ** Tree assessment
Does it mention veteran / habitat tree?	●	○	●	●	○
Does it define habitat tree	●	○	○	○	○
Does it include assessment guidelines how detailed	● ● ● ○ ○	● ● ○ ○ ○	○	● ● ● ○ ○	○
Does it include specific reference to species?	●	○	○	●	○
Does it include description of microhabitats how detailed	● ● ● ○ ○	○	○	● ● ○ ○ ○	○
Does it mention key protected species	●	○	●	○	○
Does it include practical guidance for habitat trees?	●	○	○	○	○
Does it include qualification requirements?	●	○	○	○	○

● yes ○ no ● ○ ○ ○ detail

Good example

The Czech standard on Special tree treatment includes a valuable guideline on the recording of species associated with a tree. Below is a summary of the guidance:

In the case of identified presence of wood-decaying fungi, parasitic and semiparasitic plants and other types of diseases, pests and other relevant accompanying organisms, it is advisable to specify the species of the organism detected and the place of its presence.

The records should register notably signs of the presence of Red List species.

Records on accompanying organisms shall include:

- scientific name of organism (or identification of group of organisms),
- location of presence of the symptom detected,
- characteristics of presence,
- finding date.

Protection also relates to all developmental stages of the species, and its biotope is protected as well.

Elements with increased biological potential are notably: cavities, split wood and cracks, rot, dry branches, bark damage, sap outflow, broken branches, minor cavities and perennial fungus fruiting bodies.

The presence of organisms bound to a tree may be attested by the below circumstances, which have to be recorded in the assessment report: movement of birds, bats or beetles, presence of bird nests, presence of inhabited cavities (movement, presence of droppings or acoustic manifestations), presence of large insect galleries or exit holes, presence of cavities with dry rot (particularly if containing beetle larvae, body remains or droppings), acoustic manifestations of younglings and adults, presence of characteristic fruiting bodies.

Any absence of proof of presence species in the Nature Protection Finding Database does not mean that those species are not present there. Therefore, examination in trees that might be a potential biotope for these species always has to be carried out.

When assessing a tree that is a biotope, the fact has to be pointed out. Any intervention in such a tree requires an exemption from restrictions for specially protected plant and animal species.

In suspicion of presence of protected species in a tree, cooperation with a specialist (zoologist/mycologist) is required.

Table 2. Comparison of technical standards

COUNTRY Title of standards	**CZ** Special tree treatment	**CZ** Pruning of trees	**CZ** Tree felling	**CZ** Crown security systems	**PL** Tree pruning and care	**EU** Tree pruning standard
Does it mention veteran / habitat tree?	●	○	●	○	○	●
Does it include specific reference to species?	●	○	○	○	○	○
Does it include types of microhabitats	●	○	○	○	●	○
Does it mention key protected species	●	○	○	○	○	○
Does it include practical guidance for habitat trees?	●	○	●	○	○	●
how detailed	● ● ● ○		● ○ ○ ○			● ● ○ ○
Does it include qualification requirements?	●	○	○	○	○	●

● yes ○ no ● ○ ○ ○ detail

Good example

Polish tree pruning standard includes guidance on dealing with protected and valuable species during tree work. Below is a summary of the guidance:
All work done on trees or in their vicinity should take account of the potential or possible presence of accompanying organisms and in particular those enjoying the status of protected species. Indeed, the presence of such organisms may be regarded as a probable circumstance where trees are in the over-mature phase or in other ways display enhanced natural value (for example given the presence of holes, decay, decayed wood-mulch, etc.). There is an absolute requirement that due care be taken to prevent damage and destruction to the habitats of species of value and protected species (or indeed the scaring of animals present on or in trees), both at the time a tree is being accessed (e.g. where climbing or the use of equipment damages protected lichens or causes birds' nests to be lost) and as actual work on a tree is being carried out (e.g. through the removal of a part that includes a hole resided or nested in by birds, bats, invertebrates and so on). Before proceeding to work on a tree, a person should engage in reconnaissance, with a view to determining the potential presence on a tree of habitat for protected species. It will need to be recalled that:

- scientific name of organism (or identification of group of organisms),
- location of presence of the symptom detected,
- characteristics of presence,
- finding date.

It further needs recalling that there are prohibitions on the scaring and disturbing of animals (where the term "animal" is taken to include birds), with this denoting a need to take heed of this condition irrespective of the type of work to be carried out on a tree. Where the party commissioning work on a tree has failed to obtain a permit offering exemption from the prohibitions in force, it will be necessary:

- to abandon the pursuit of the work in question,
- to inform the Employer that a given tree constitutes a site or habitat for protected species,
- to inform the Employer that the work might recommence once the necessary permits have been issued by a Regional (or in certain cases by the General) Environmental Protection Inspectorate,
- to carry out work with all due care even where the aforesaid permits or consents have been obtained.

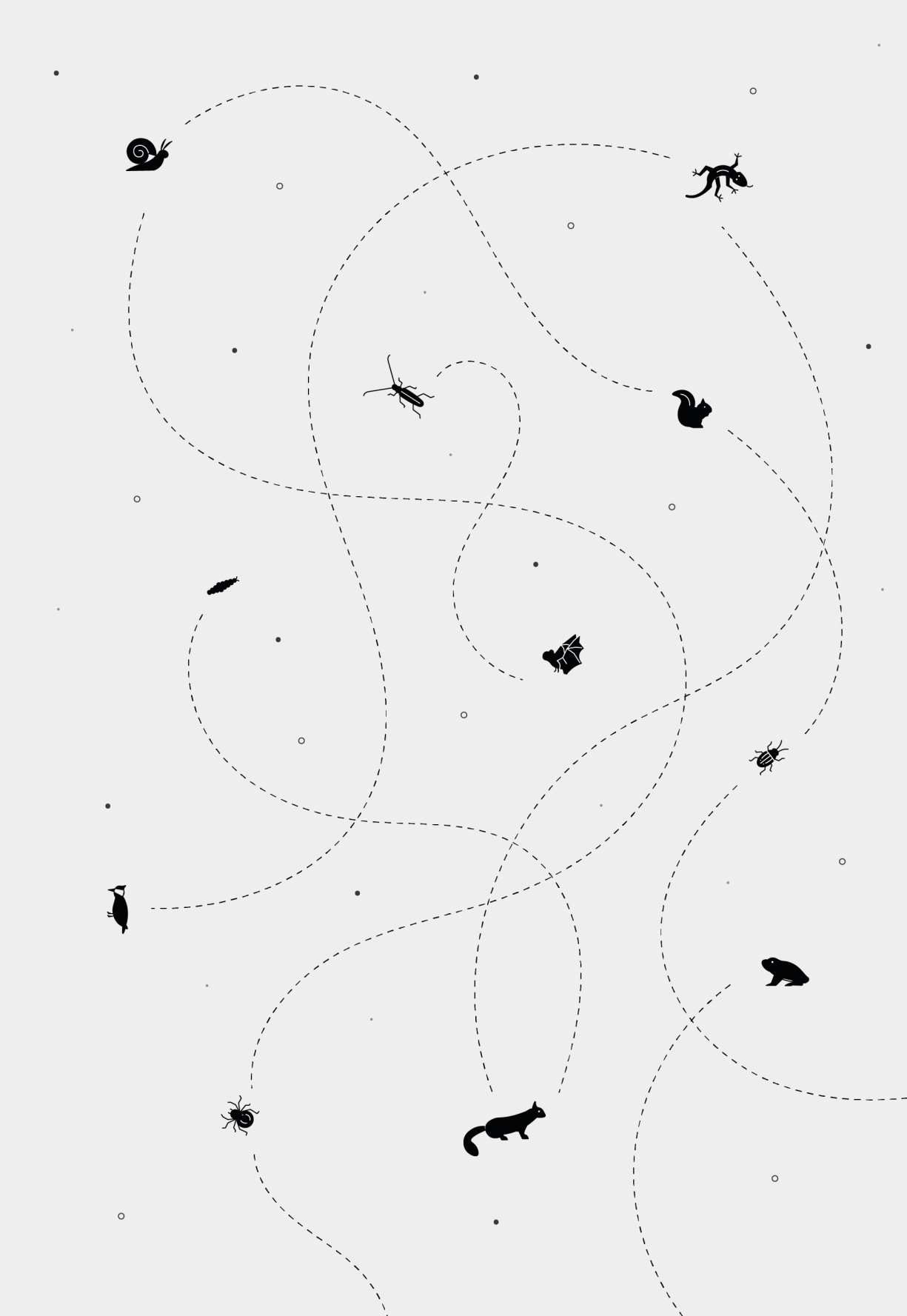
Overall, there is a requirement to minimise as far as possible the destruction or damage of sites of habitats for protected species.

Felling standards
In general there are no standards related directly to tree felling. Removal of trees is most commonly present in health and safety documents related to use of tools such as chainsaw or working at heights. Therefore guidance on the removal of trees in relation to their habitat is rather scarce.

Summary of review

The review of standards and practices indicates a lack of common standards in dealing with veteran or habitat trees. This applies both internationally and within individual countries. The key findings of the review include:

1. In general, arboricultural standards are lacking detailed reference to veteran and habitat trees. One of the reasons might be the complexity of these trees and individual character which makes it challenging to present in a standardised way.
2. There is a diversity of terms and definitions used to describe trees with similar characteristics. Therefore it is advisable to include clarifications of definitions for the better understanding of veteran and habitat trees.
3. A number of standards includes cross-reference with other documents. Sometimes these are not presented in a clear way, therefore it is recommended to increase the quality of referencing documents that have similar content.
4. Lack of guidance on competences and skills for those involved in veteran tree management - veteran tree management is a complex task that requires an appropriate level of knowledge and skills – in this respect arboriculture is a multidisciplinary profession that influences public health and safety. It is crucial to have competent specialists to provide the best result. This can only be achieved with substantial and well-structured training.



5. Recommendations

Based on the review of approached to the management of veteran trees below are presented some of the valid and important practices divided into three main parts: tree assessment, competences and tree care (site amendments and pruning).

Criteria for identifying veteran trees

In order to identify veteran status of trees it is important to become familiar with the concept of tree development phases, from young to ancient.

The life of a tree is usually thought of as a linear process, starting with the seed, continuing through youth and maturity to old age and death. However, this approach does not fully take into account the subtleties of the complex and dynamic nature of tree ageing. In addition to the early stages of a tree's life, developmental phases can affect the whole tree or parts of it, and can recur in cycles in different periods of a tree's life. The French scientist Pierre Raimbault (1995, 2006), observing the physiological-morphological processes in trees under the influence of hormones, species characteristics, habitat conditions and other conditions, divides the life of a tree from seed to death into 10 phases.

From young to mature tree (phases 1 to 4)

In the first phases, energy is spent on optimising the assimilative surface area and the trunk climbs upwards at the expense of growth in thickness. Apical dominance is initially very strong. As it weakens at the end of phase 4, branching develops. The root system, initially simple, gradually branches out more and more, responding to the development of the crown and creating multi--level structures.

Mature tree – early, middle and late stages (5-7)

During this phase of development, the crown rounds off and the vitality of the peripheral parts of the crown (including the lower parts) weakens. At the end of phase 7, the crown reaches its maximum height, extent and production capacity. This is equivalent to the imaginary optimum of a mature tree. The crown, under the influence of the root system and peripheral vitality weakening, loses some of its branching complexity. The center of gravity of the crown starts moving downwards. With the disappearance of apical dominance, individual branches assert their independence and competition between them becomes more apparent.

This has consequences for the hormonal economy and the accumulation of sugars. The root system fragments itself accordingly, according to the demand of the parts of the crown it feeds. In this phase, the photosynthetic capacity of the tree reaches its maximum. During the last phases, the taproot and other initial parts die off and the decomposition of the stem base begins. At this stage, the relationship between the crown, trunk and root parts gradually becomes more individualised and complex.

Ancient tree – early, middle and late stages (stages 8 to 10)

During phase 8, the progressive death of roots and the decay of the root system and the lower part of the trunk by fungi become more noticeable. At the end of phase 9, changes in the hormonal and water balance cause crown retraction. As the crown shrinks and lowers, energy, water and nutrients are translocated into the solid crown of the aged tree. New shoots emerge from dormant buds and adventitious buds located on the trunk and main branches. By stage 10, the conduction is split at the periphery and separate cambium columns linking the crown to the root system are formed. The longevity of the tree depends mainly on the efficiency of the emerging conductive columns and their connection to the root system. In phase 10, a complex system of partly or completely independent mini-trees (corresponding to phases 3 to 5) grows within the mother tree, benefiting from the life experience of the adaptive capacity stored in its genetic memory. The ageing process triggered does not necessarily lead directly to the death of the tree. It can be a transitional phase, leading to the rejuvenation of part or all of the tree. The key to successfully caring for a ancient tree is to understand the aging process, its strategy as a colony organism, reacting and adapting as much as possible to changing external conditions.

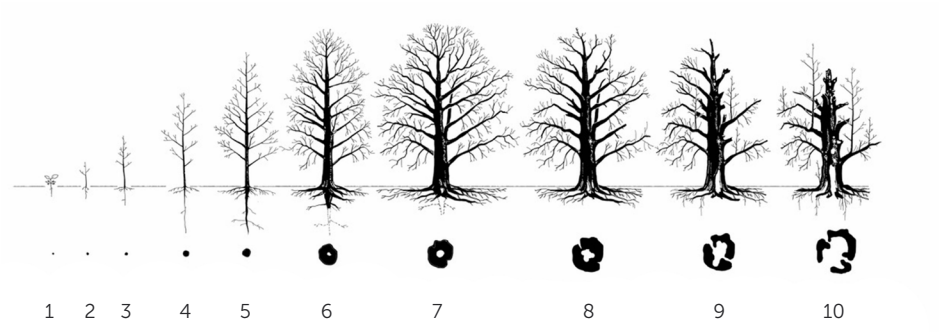


Fig. 3. Tree development stages (source: Trees - a Lifespan Approach, Fig. J. Józefczuk)

Table 3. Classification of tree development stages and criteria for the identification of veteran trees. Based on Trees – a Lifespan approach, by Neville Fay.

	Tree development phase	Microhabitat potentcial	Vetaran status	
Non-ancient	**1-4 young**	Poor habitat, high vigour. Minimal amount of non-functional tissue.	○	
	5-6 mature	Crown expansion, early stage of loss of apical dominance.	○ ●	at least 3 features of veteran tree
	7 late mature	Growth up to maximum crown size, colonisation by fungi, beginning of natural branch loss, increasing proportion of non-functional wood, fungal activity underground initiates decomposition of the trunk interior at the base.	○ ●	at least 3 features of veteran tree
Ancient	**8 early ancient**	Beginning of crown remodelling; decrease in living crown, intensification of lower crown growth, increased fungal activity – development of saproxylic habitat of trunk interior and large branches, formation of cambial columns.	●	
	9 middle ancient	Advanced retrenchment and reduction of the living crown and annual increments, death of branches within the crown, induced by shading of outermost branches, breakage of branches and associated emergence of shoots, decay of the stem interior – formation of hollows, intensified colonisation by insects, birds and lichens, intensification of reiterative growth in the crown and trunk, maximum saproxylic activity.	●	multiple features of veteran tree, especially - cavities and trunk decay - lots of tree-related microhabitats (incl. hollows and cavities in canopy) - shedding the canopy
	10 late ancient	Reduced viability, saproxylic habitat, community of fungi and other organisms; intensification of root decomposition and nutrient recycling. Trees may die or rejuvenate.	●	

● veteran ○ non-veteran

This understanding causes us to approach ancient trees with humility, respect and attentiveness. We recognise that they are valuable and complex organisms about which we still know very little. Knowing the cases of trees whose crown tops have died off, but are still going strong, we can see that the death of a peripheral part of the crown does not mean the death of the whole tree. It may just be one of the phases of its development. When carrying out maintenance, we should draw conclusions and knowledge from observations of natural processes.

Assessment of veteran trees

Ancient or veteran trees will have a rotten and hollow trunk, often with fungal fruiting bodies. In the crown, one can notice the gradual death of the upper branches and the appearance of new ones in the lower part of the plant or on the trunk. Many veteran and ancient trees would not have lived to see the present day if they had once been classified as dangerous or dying because of these symptoms. These veterans are on good terms with their numerous tenants, including fungi, and have remained in a delicate balance with them for centuries.

But how do we distinguish between the natural ageing process and the premature death of a tree due to deteriorated environmental conditions, root damage, a severe fungal or bacterial infection or massive insect feeding? Ageing is gradual and usually starts at the top. The rest of the crown shows the normal vitality of an ageing tree, and the new shoots appearing in the lower part may even have youthful characteristics. In the case of disease or damage, the decline of branches is usually more rapid, sometimes even violent, and is usually accompanied by a general weakening of the vigour of the tree and sometimes by disease-specific symptoms. Root damage, on the other hand, can be identified by symptoms in the area around the tree, such as signs of excavation, soil compaction or changes in soil level. If you are unsure of the reason for the appearance of increased branch dries, investigate other possible causes – root damage, disease – and then observe the tree. It could be that the tree is preparing itself for a long life ahead.
You should evaluate the different parts of an aged tree separately. Some may be dying, while others are being rejuvenated. In all cases, careful diagnosis is the starting point for careful care planning.

Tree care plan

The standard approach which is characteristic of young and mature trees does not work for old trees, because they function differently and react individually. The development period of aged trees is longer than the lifespan of a human being, and the required multi-year interval between repeated treatments is usually beyond the horizon of a single contractor. As with a forest management plan, a tree care plan for ancient trees ensures continuity of care and increases the chance that the tree will be preserved in good condition. It is advisable to photograph the specimens before and after treatment and to include the photos in the care plan documentation. In the UK, individual tree management plans are drawn up for 20 years and modified along the way, based on the tree's response to previous management.

The plan gives a course of action based on what was observed at the time the plan was developed, but usually does not give a specific solution, as this will be based on how the tree reacts to subsequent treatments, planned in response to the previous condition of the tree. It may be that the tree is in danger of failing and radical pruning is necessary, but this should be considered as a last resort. Remember to only remove live branches and boughs when necessary, because the only source of energy for plants is the growing leaves.

Facing the threat of collapse

Many veteran and ancient trees do not require any intervention. They often grow in fields and forests, away from roads and buildings, so even if they have dry branches and boughs, they are not dangerous. We only intervene in a few specimens that pose a danger to people, and it is not possible to restrict the use of the land around these trees. In a few situations, the aim may be to prolong the life of an old tree, which we would like to preserve because of its priceless value.
The key is to strike a balance between providing adequate nutrition for the tree and preventing the tree from falling down or the main branches from breaking off (especially in neglected/lapsed pollards). At the same time, the longer adaptation time to any changes in old trees must be taken into account. Removing a significant part of the crown, which is sometimes necessary, can rob a tree of its energy to such an extent that it starts to die.
Before you take the saw to the tree, make sure that there is no other way to make the tree safe, for example, by fencing it off, using tree cabling or other mechanical support systems. If the lower crown is already well developed, you can sometimes afford to radically remove the affected part of the tree. If, however, there is no lower crown yet, it is necessary to induce its formation with appropriate measures.

5. 1. How to conduct survey

Surveying veteran or habitat trees requires additional parameters compared to basic tree inspection. Below is a summary of parameters that have been used in various methods. One of the most popular and widely used is the Specialist Survey Method (SSM) developed by the Woodland Trust in the UK. The value of veteran trees increases with the presence of habitats for valuable and protected species, as well as with the presence of potential habitats, mainly related to dead, decaying wood, the presence of hollows, deadwood, etc.

I. Tree vitality (based on Polish tree assessment standard)

This is independent of the stability assessment, even as it is a component part of the assessment regarding a tree's condition. The vitality assessment makes use of a modified Roloff scale.

Given the way in which different parts of a tree may show differentiated levels of vitality, the feature is in principle assessed in regard to the whole upper third of the tree crown. Furthermore, vitality needs to be viewed from the point of view of the tree's development. A young and healthy tree typically shows 0, while a maturing one rates a 1, and a mature specimen a 2. Over-mature trees and those now gradually dying off do not match any particular depiction in line with the Roloff Scale, with a detailed diagnosis in relation to the crown potentially therefore requiring separate vitality assessment.

Offshoots are usually depicted for a 2 on the scale (i.e. a 1 after Roloff), in fact irrespective of the overall vitality of the tree as such. This in turn dictates that they should be excluded from any overall assessment. Vitality is described in line with the scale below (after the aforesaid Roloff):

Table 4. Roloff scale of tree vitality

Number after Roloff assigned for degree of vitality	Description
0	The tree is in a phase of strong incremental increases in the length of stems, with this being true both apically and in relation to the side branches (the two categories both growing dynamically and evenly, with mostly long stems produced). A dense and even foliage has been generated by the time summer arrives.
1	The tree has slightly reduced stem increment, side branches are more truncated than in the apex, and with free space appearing between those present in the crown, visible even when the tree is in full leaf.
2	The tree has distinctly curtailed incremental growth of all its stems (only short stems are present), and is characterised by little or no further growth in height, while distinct gaps in the crown are to be noted when the tree is in full leaf.
3	The tree shows varying degrees of dieback in different parts of the crown.
n/a	The tree is dead.

II. Tree health (based on Polish tree assessment standard)

Tree health is a measure of the ability of a tree to carry out all life processes properly, including compensating for tree damage and other negative influences from the living and non-living environment. The response of a tree to existing damage is not assessed in terms of its stability, but the effect of the damage on the health of the tree. A distinction should be made between tree health and tree stability.

Factors influencing the assessment of tree condition:

- the condition of the assimilation apparatus (e.g. leaf colour, unnatural appearance, chloroses, presence of pathogens),
- the presence of damage which affects the vital processes of the tree (e.g. necrosis, mechanical damage),
- reactions to the damage occurring (e.g. rate of growth of the tree tissue, occurrence of reaction wood),
- occurrence and importance of diseases and pathogens, vitality in the context of the developmental phase of the tree,
- environmental and habitat conditions.

The assessment levels are described on the basis that the more parts of the tree are weakened, the weaker the condition. For example, if only a small part of the crown (individual shoots) shows weakness, then the tree as a whole will still be in relatively good condition. However, if there is a feature on the trunk, for example extensive necrosis, which affects the nutrition of all parts, the condition of the whole tree will be assessed as severely weakened.

Table 5. Scale of tree health based on Polish tree assessment standard

Scale of tree health	Description
1 very good	• lack of damage within the crown and trunk worth noting • no great amount (only up to a 10 % incidence) of deadwood arising through natural processes and having no influence on tree physiology • no damage to the assimilatory apparatus • no signs of disease or the presence of pathogens is to be noted • permissible wounds are present following measures taken in the proper way (there is a very good reaction to wounding, with scar tissue overgrowing slowly and with wounds therefore closed or closing) • concordance between vitality classes after Roloff and the phase of development of the tree
2 good	• signs of (up to 30%) damage to the roots still of limited significance to the tree's overall condition • limited damage affecting (up to 30 % of the circumference of) the trunk and boughs, with the influence on physiology limited in consequence • deadwood of up to 30 %, influencing the physiology of the tree to only a limited extent • up to 30% damage to the assimilatory apparatus, sufficient to exert only a limited influence on tree physiology • diseases present do not exert a greater influence on the condition of the tree • there is a weak but noticeable reaction to wounding, with overgrowing scar tissue • the fruiting bodies of fungi that are present are of limited significance to the tree's condition
3 impaired	• signs of (up to 50 %) damage to the roots, sufficient to have a clear influence on the condition of the tree • damage affecting (up to 50 % of the circumference of) the trunk and boughs, with a consequent distinct influence on the physiology of the tree • the trunk and main branches of the tree feature single fruiting bodies of species of fungi

Scale of tree health	Description
3 impaired	• deadwood of up to 50 %, having a distinct impact on the tree's condition • up to 50% damage to the assimilatory apparatus, sufficient to exert a marked influence on the condition of the tree • in the crown part, up to 50 % of its volume has signs permissible as indicating root damage, e.g. with raised ground level etc. • there is an impaired reaction to wounds (on trunk and main branches) that are of significance to the physiology of a weakened tree • wound tissue not overgrowing nicely and wounds not therefore healing • diseases present are capable of exerting an influence on the whole tree (denoting an impairment or weakening of condition) • if there are more than two key features indicative of an "impaired" condition, the tree should be classed as "much impaired", and hence given a 4
4 severly impaired	• signs of (more than 50 %) damage to roots, having a major influence on the condition of the tree • damage to the trunk base, trunk and main branches (extending around more than 50 % of the circumference of the tree or branch) is exerting a significant influence on tree physiology • extensive wounding along the trunk and boughs (around more than 50 % of the circumference), hence with a major influence on tree physiology that hinders the conducting of assimilates; • very limited or zero reaction to wounding (scar tissue does not grow over) • the presence on the trunk and main branches of numerous fruiting bodies of species of fungi is sufficient to influence physiology of the tree significantly • deadwood account for more than 50 % of crown volume • more than 50 % of crown volume is characterised by damage to the assimilatory apparatus • diseases present are leading to serious impairment of the tree's condition
5 critical	• most of the tree is dead or dying (afflicted by irreversible damage)

III. Tree stability (based on Polish tree assessment standard)

The stability of a tree needs to be assessed and analysed in detail, even if the tree looks healthy and its condition is faultless. Stability assessment refers to the probability that a tree or part of it will fall. Among other things, diagnostic characteristics, the habitat and environment of the tree, as well as defensive and compensatory reactions are taken into account when assessing stability. The stability of a tree does not necessarily correlate with its condition, which is why we evaluate these parameters separately.

The inspection shall assess the probability of breaking (splitting off) part of the tree and/or the likelihood of whole tree toppling over. it should be based only on symptoms detected using the eye or simple tools (probe, hammer, binoculars).

As with the condition assessment, the degree of stability assessment depends on the proportion of the tree affected by the diagnostic characteristics. If the observed feature concerns small parts of the tree and does not affect the whole tree, then the tree stability rating will be „good" or „very good". If, however, the set of diagnostic characteristics affects the whole tree, then the degree of rating on the scale should be higher (i.e. the rating stability weaker).

Table 6. Scale of tree stability based on Polish tree assessment standard

Scale of tree stability	Description
1 **very good**	• absence of features impairing the stability of the tree or parts thereof • no tangible signs of a threat of the whole tree or part thereof falling (or of the tree being toppled or uprooted) • the tree is too small or young to pose a threat even were the risk of the whole tree or part thereof falling to arise (or else the risk of its being toppled or uprooted) • limited presence of deadwood up to 3 cm in diameter • limited (up to 5 %) presence of deadwood up to 5 cm in diameter • diagnostic features are at such a low level of occurrence that the tree requires no measures whatever
2 **good**	• absence of features impairing the tree's overall stability • some limited decay now affecting wood in the trunk and main boughs, with single tree-holes or cavities present • impaired branching within the crown • presence of features impairing the stability of branches more than 10 cm in diameter • limited deadwood (up to 10 % and with a diameter of up to 10 cm) • presence of single broken branches (of diameters up to 10 cm) suspended in the crown • level of occurrence of a feature can usually be kept in check by way of basic measures (e.g. dead-branch removal, pruning to thin the crown), indicating that specialist work does not need to be resorted to

Scale of tree stability	Description
3 impaired	• decay or loss of (up to 50 % of) main skeletal roots around the circumference of the tree • unnatural inclination of a tree showing signs of compensatory growth • trunk decay present over up to 50 % of the cross-sectional area • cavities extending to up to 50 % of the circumference of the trunk • presence (on root folds, at the trunk base or along the trunk) of individual fruiting bodies of species of fungi whose growth is capable of impairing a tree's stability • impaired forking of the main boughs • a significant (up to 50 %) share of deadwood of diameter up to 10 cm • presence of several features still at an early stage of development • the range and extent of features are such that specialist measures (such as technical pruning, tying, etc.) will usually need to be pursued to limit risk
4 severely impaired	• considerable (more than 50 %) decay of skeletal results, trunk and boughs • recent tipping of tree showing signs of a loss of stability in the ground • fruiting bodies of fungi have appeared on the root buttresses, around the trunk, and on the trunk and boughs • there are many holes and cavities along the trunk and main branches (over more than 50% of the girth) • there are splits and fissures across the trunk and main branches • forking of the main trunk and boughs is weakened (with included bark and splits) where the diameter of trunk or boughs exceeds 25 cm • deadwood at a level of more than 50% or involving girths greater than 10 cm • suspended and broken large branches of diameters over 10 cm are present • features are of such a scope that they may usually require specialist measures (as the features are capable of weakening the whole tree considerably and are likely to abbreviate its prospects of going on living, the action to be taken as an alternative to removing the tree)
5 critical	• the state of a tree poses a direct threat to property, or human life and health • stabilisation of the tree can only be achieved if there is major damage or destruction in the process, in the face of a lack of other possibilities to safeguard the tree's surroundings • the extent of the feature or defect is such as to require that the tree be removed – the alternative would at best be to leave a so-called witness tree • immediate intervention is often necessitated

IV. Standing/lying (parameter based on the SSM method)

This parameter indicates the position in which the tree (main trunk) is located. The following characteristics have been used: standing, fully lying, much leaning, scrap – broken trunk.

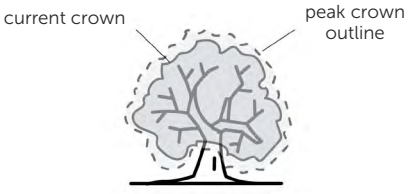
- **standing** – the trunk is more or less upright
- **much leaning** – the trunk is leaning at strong angle for the ground with the rootplate fully or partially attached to the ground
- **collapsed** – main trunk is lying on the ground partially attached or entirely detached from the ground
- **scrap** – broken trunk – the trunk is fractured attached to the parent tree or separated

standing **much leaning** **collapsed** **scrap**

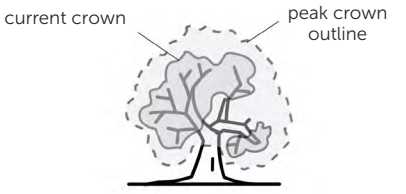
V. Crown loss (parameter based on the SSM method)

This parameter indicates how much of the original crown of the tree has been lost. Crown loss is a comparison between the current size and shape of the crown and the probable size of the full crown the tree had when it was at its peak. Parameter estimated and determined with one of four.

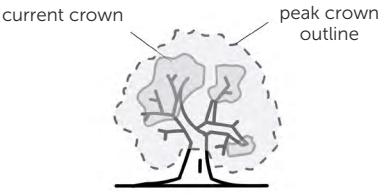
- **full or almost full crown outline** – the current framework is reduced by less then 25 % of likely peak crown framework (the tree has shed less then 25 % of its likely peak crown framework)
- **reduced crown outline** – current framework of the canopy is reduced by 25-50 % of estimated peak crown framework (the tree has shed 25-50 % of its likely peak framework)
- **partial (fragmentary) full crown outline** – the actual crown size is reduced by 50-75 % compared to the estimated peak crown framework (the tree has shed 50-75 % of its likely peak crown framework)
- **remnant crown outline** – the tree has shed over 75 % of likely peak crown framework



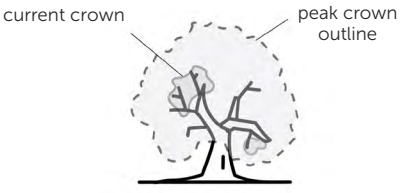
full or almost full crown outline



reduced crown outline



partial full crown outline



remnant crown outline

VI. Live crown (parameter based on the SSM method)

This parameter indicates how much of the current crown is alive. Parameter estimated and determined with one of the five possibilities below:

- **live canopy** – mostly full canopy is covered with live growth
- **live partial canopy** – 25-50 % of the actual crown outline is living
- **live residual canopy** – less then 25 % of the crown has live growth
- **crown is dead** but the trunk has some live growth
- **no live growth** – the whole tree is dead

live canopy

live partial canopy

live residual canopy

crown is dead

no live growth

VII. Offshoots (parameter based on the SSM method)

The presence of offshoots/regenerative shoots that have developed in response to damage or environmental changes is assessed. The presence of suckers on trees indicates the different vitality of different areas or parts of the tree. The parameter indicates whether regenerative shoots are present on the tree with the indication of the part of the tree where they are present: B – stem base, T – trunk, C – crown, BT – stem base and trunk, BC – stem base and crown, TC – trunk and crown, N – none.

offshoots on stem base

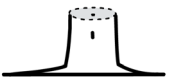
offshoots on trunk

offshoots in crown

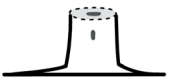
VIII. Hollows (parameter based on the SSM method)

Open hollows in the trunk base, trunk and main branches are assessed. The process of hollowing could be continuous or partial. The assessment is carried out according to the following guidelines:

- **apparently solid trunk** the circumference is full, but there are small cavities
- **hollow trunk** the circumference is full, but small holes may be present
- **partially solid trunk** the circumference is incomplete, with major cavities and large openings
- **remnant trunk** incomplete shell up to 30% of the outer circumference is missing
- **remnant trunk** more then 30% of the outer circumference is missing



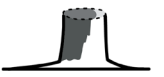
apparently solid trunk



hollow trunk

partially solid trunk

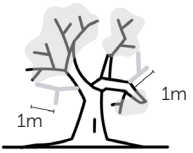
remnant trunk



remnant trunk

IX. Deadwood (parameter based on the SSM method)

The parameter defines the number of units of dead limbs present in the crown of the tree. One unit includes a piece with a length of 1 m and a diameter of 15 cm.



X. Number of associated species

The presence of associated species should be taken into account in the tree assessment and species names should be provided where possible. When noting the observed presence of associated organisms the following is specified:
- the species name of the organism (or if this is not possible, the generic name),
- the location of the detected organism (base of stem, trunk, branches, crown),
- frequency of occurrence (O – occasional, F – frequent, A – abundant, D – dominant).

XI. Tree-related microhabitats

The presence of microhabitats should be noted during veteran tree assessment. The habitat features can be quantified for population management purposes. These features include:

- **rot holes**
- **rot sites**
- **dead wood**
- **hollowing**
- **fungal fruit bodies**
- **split limbs**
- **tears and necrosis**
- **scars**
- **live stubs**
- **insect galleries**
- **woodpecker breeding cavity**
- **epiphytic and parasitic cryptogams and phanerogams: vascular plants, mosses and lichens**
- **nests: vertebrate or invertebrate nests**
- **microsoil – a small amount of newly-created soil originating from the decomposition of organic matter from twigs, leaves, bark or mosses**

Number of microhabitats should be noted. It can be divided into tree parts:

Tree part	Root system	Trunk base	Trunk	Main limbs	Crown
Number of microhabitats					

Trees of any diameter that show 4 or more of the above features are recorded as veterans for the purposes of this survey. Such trees are regarded to show habitat characteristics consistent with ancient trees.

XII. Shade – (parameter based on the SSM method)

The parameter indicates whether the tree is shaded and is determined on the following scale:

- **no shading**
- **little shading**, one or two sides
- **significant shading**, three or four sides
- **heavy shading**, one-two sides and from above
- **heavy shading** from above and from all sides

top view

section view

no shading

top view

section view

little shading

top view

section view

significant shading

top view

section view

heavy shading

top view

section view

heavy shading

XIII. Additional information – comments, description

Any additional factors and charasteristics might be added to the description of surveyed trees. These might include the history of the work carried out, landscape context, etc.

5.2. Guidelines for competences

Care of veteran and habitat trees requires special set of competences and skills. VETCert certification scheme provides a detailed description of skills and knowledge for practitioners and consultants involved in veteran tree management. These can be found online https://www.vetcert.eu/standards-certificates

Still, the teaching guidelines also include special assessments, e.g. assessment of mechanical support systems, soil, as well as the evaluation of tree condition based on the crown aerial assessment. A tree assessor performing advanced diagnostics should also be aware of less frequently used methods and techniques, and keep up to date with modern technologies. One of the important elements in the preparation and training of a tree assessor at this level should be proper project management, communication and development of documentation. The ability to prepare action plans and advanced recommendations is also the domain of tree assessors performing more advanced tree assessment. Advanced diagnostics is not only about the knowledge and skills of using more specialised techniques or tools. It is also about competencies in a holistic and long-term understanding of the tree and its surrounding area on a strategic level, as well as the ability to provide the recipients of tree assessment with specific recommendations.

5.3. Recommendations for pruning veteran trees

Pruning of veteran and habitat trees should be performed according to local pruning standards. Based on the review of guidelines and standards, below are some general guidelines for pruning veteran/habitat trees:

- always consider alternatives to pruning when working on habitat trees;
- before pruning is performed make sure to inspect each microhabitat for the presence of other species. If protected species are present stop the work and consult with a specialist for further actions;
- if pruning is necessary do not cut through wholes, cavities and other microhabitats;
- deadwood should be retained for as long as practically possible;
- try to remove as big parts as possible, avoid small parts;
- remove the tree parts with a drop line so that the part doesn't fall to the ground;
- during the operation removed parts should stay in the similar position as on a tree;
- once the part is removed check it again for the presence of species;
- never use chippers for dealing with parts of trees that are microhabitats;
- never use grinders for dealing with stumps of habitat trees that have microhabitats in root collar.

5.3.1. Pruning pollards and lapsed pollards

In addition to general pruning guidelines, it is worth to sum-up recommendations for pollarded trees, including lapsed pollards.

Pollards are trees which are cut in a regular cycle allowing regrowth of new shoots. Traditionally these trees were maintained for wood, fodder and leaves. The length of cutting cycle depends on how well the tree grows (or the obtained product).

Lapsed pollards are trees that used to be pollarded but now are out of the pruning cycle. In Central European landscape these trees are the majority of which were pollards many years ago. After years of neglectance, the branches are much bigger and are too heavy for the tree cut regularly.

For the trees which are pruned in regular the best is to continue the pruning e.g. every 5 years.

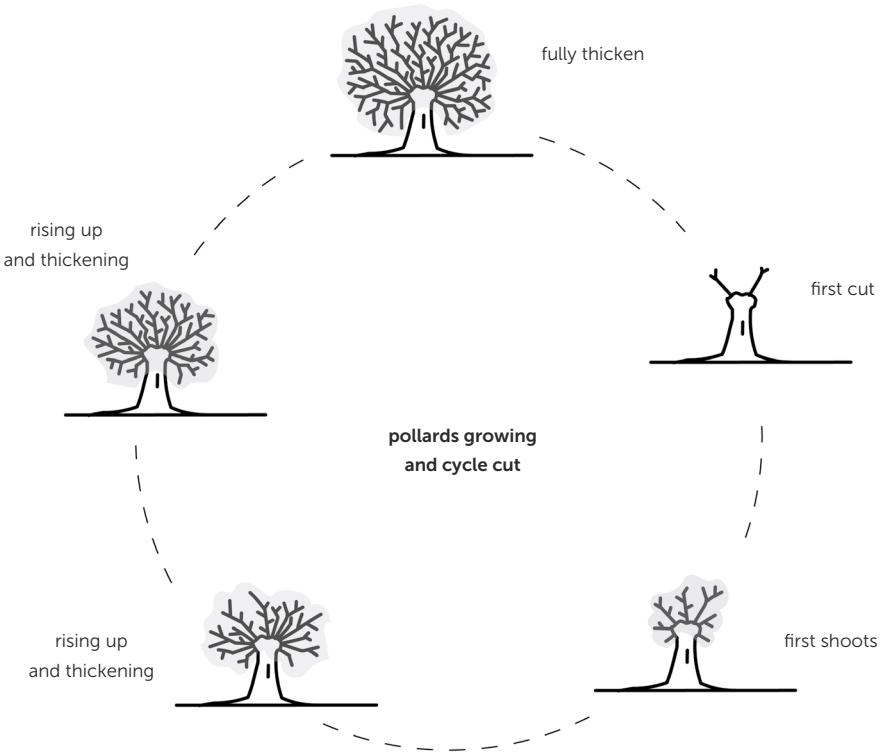
For the other trees, which are not responding to cutting as well as younger, it's better to leave some branches rather than cut them all. For the trees which are out of regular cycle, it's necessary to approach future management spread over years and divide into stages.

Removing all the branches from lapsed pollard trees frequently kills the tree or causes extensive dieback. Even if a tree responds well to heavy pruning by producing lots of new shoots, frequently it goes with extensive decay, which can be also covered and hard to identify as well.

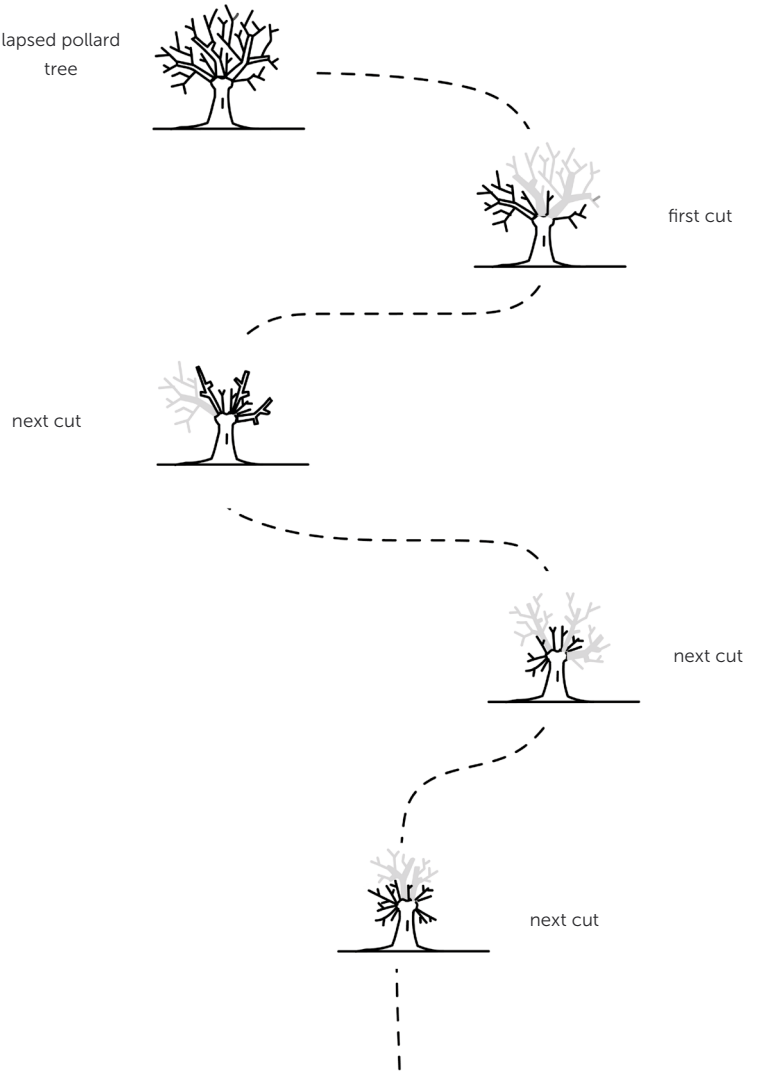
Stabilisation of lapsed pollard to more or less regular cycle needs slow progress. Pruning should cover only two to four meters from the crown at any one time. Cutting trees with lots of branches arising from the bolling should include removing the larger ones, and the smaller ones should be retained. Leaving some branches and leaves is crucial and helps the tree to survive.

Removing lower branches which encourage tree to put more energy into the upper parts of the tree is not recommended for veteran trees. Maintaining trees as pollards provides many habitats.

Pruning in cycle



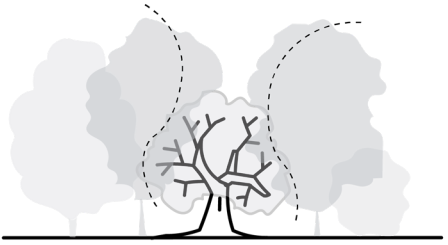
Pruning lapsed pollards



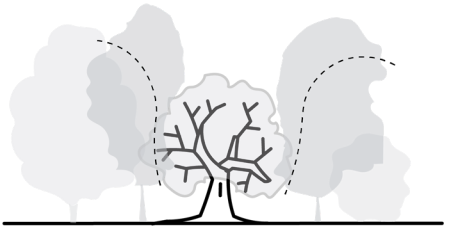
5.4. Recommendations for site management

In standards and regulations there are many aspects of the management of surrounding of veteran trees. These might include usage management, soil improvement methods and the management of the surrounding vegetation. Below are the two main methods that are commonly used and proved to be very valuable.

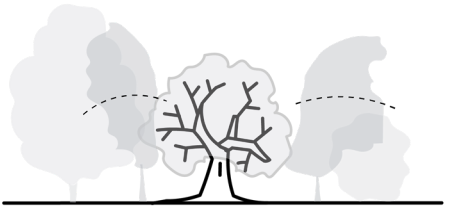
Halo clearance
It is defined as phased thinning or clearance of non-veteran trees or shrubs that are harming veteran trees by shading.



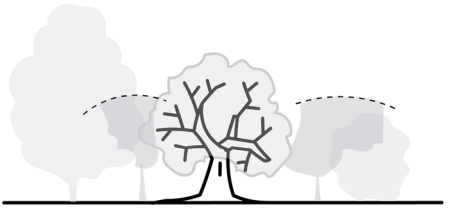
first clearance cut



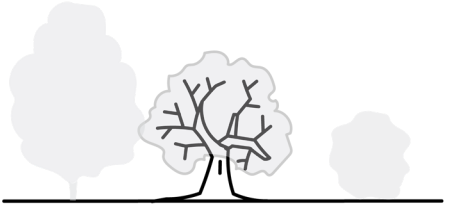
second clearance cut



third clearance cut



fourth clearance cut



Mulching

Mulching is considered to be one of the most effective ways for soil improvement. Below is a summary of the method to be applied. Mulching is the spreading of a layer of wood chips or composted bark, or a mixture of the two, to have a positive impact on both older and newly--planted trees.

The main principles of mulching:

- the soil beneath a tree should be prepared: cleared of organic debris, weeds, litter and rubble. It should also be moist;
- the mulch used (e.g. of bark or wood chips) should be composted, ground up to a fraction of 2-6 cm particle size, cleared of all litter and weeds, and free of pests and pathogens;
- the layer should be of about 5 cm (maximum 10, so as not to limit access to air) mulch should not reach up to the trunk itself, and indeed the equivalent of 1 trunk diameter should separate the base of the trunk from chipped bark applied;
- mulching should encompass the whole area of the root system, or as much of that as is possible.

5.5. Qualification of trees for felling

The best form of protection of habitat trees is simply leaving them in place, combined with care for the surrounding stand in which the succession of generations is undisturbed by felling.

Instead of felling, skilful removal of unstable parts may be recommended, if the traffic conditions require such actions. Even in the case of completely dead trees, it is advisable to cut off the branches and leave the main trunk in place for a few more years to allow further development of microhabitats.

In case of animals (especially bats, birds and insects) one of the greatest risks is the damage from chainsaws to animals that are inside the tree. In order to minimise the risk of killing them, it is important to anticipate where they may be inside the tree. So it is important to leave high stumps and never cut through habitat features.

Once a tree has been felled, it is important to assess whether it is currently colonised. This assessment involves a careful review of the humus content, first in the remaining stump and then in the rest of the lying log.

Literature

ATF (2008). Ancient Tree Guide No. 4: What are ancient, veteran and other trees of special interest? Ancient Tree Forum, c/o The Woodland Trust, Grantham.
ATF (2009). Ancient Tree Guide No. 6: The Special Wildlife of Trees. Ancient Tree Forum, c/o The Woodland Trust, Grantham.
Boddy, L. (2021). Fungi and Trees. Their Complex Relationships. Arboricultural Association, Stonehouse.
Borowski, J. Witkoś-Gnach, K. (2021). Tree pruning and care standard. Fundacja EkoRozwoju, Wroclaw.
BSI (2010). Tree work – Recommendations: British Standard 3998:2010. British Standards Institution, London.
BSI (2012). Trees in relation to design, demolition and construction – Recommendations. British
Bütler, R.; Lachat, T.; Krumm, F.; Kraus, D.; Larrieu, L., 2020: Field Guide to Tree-related Microhabitats. Descriptions and size limits for their inventory. Birmensdorf, Swiss Federal Institute for Forest, Snow and Landscape Research WSL. 59 p.
Standard 5837:2012. British Standards Institution, London.
Dujesiefken, D. Jaskula, P. Kowol, T. Lichtenauer, A. (2018). Baumkontrolle unter Berücksichtigung der Baumart. Bildatlas der typischen Schadsymptome und Auffälligkeiten. 2., überarbeitete und erweiterte Auflage, Haymarket Media, Braunschweig.
Dujesiefken, D., Stobbe, H. (2002) The Hamburg Tree Pruning System – A framework for pruning of individual trees. Urban For. Urban Green. 1, 75–82.
Dunster, J. A.; Smiley, E. T.; Matheny, N.; Lilly, S. Book. (2017). Tree risk assessment manual 2017, ISA.
Dworniczak, Ł., Reda, P. (2021). Protection of trees and other plants in the investement process standard. Fundacja EkoRozwoju, Wroclaw.
European tree pruning standard EAS (EN) 001:2021. (2021). European Arboricultural Standards EAS.
European cabling and bracing standard EAS (EN) 002:2022. (2022). European Arboricultural Standards EAS.
Fay N. (2002). Environmental arboriculture, tree ecology and veteran tree management. Arboricultural Journal; 26(3):213 – 238.
FLL (2020). Baumkontrollrichtlinien – Richtlinien für Regelkontrollen zur Überprüfung der Verkehrsicherheit von Bäumen, Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau e. V., Bonn.
Hirons A., Thomas P. (2018). Applied Tree Biology. Wiley, Oxford.
Humphreys, D., Wright, C. (2021). Fungi on Trees. A Photographic Reference. Arboricultural Association, Stonehouse.
Humphrey, J. & Bailey, S. (2012). Managing deadwood in forests and woodlands. Forestry Commission Practice Guide. Forestry Commission, Edinburgh.
Larrieu L, Paillet Y, Winter S, Bütler R, Kraus D, Krumm F, et al. Tree related microhabitats in temperate and Mediterranean European forests: a hierarchical typology for inventory standardization. Ecol Indic. 2018;84:194–207Main reference of the typology of TreMs.
Lichtenauer, A., Kowol, T., Dujesiefken, D. (2011). Pilze bei der Baumkontrolle. Haymarket Media, Braunschweig.
Lonsdale D., (red.). (2013). Ancient and ocher veteran trees: further guidance on management. The Tree Council, London.
Matheck C., Bethge K., Weber K. (2015). The Body Language of Trees. Encyclopedia of Visual Tree Assessment. Karlsruhe Institut of Technology.

National Tree Safety Group NTSG. (2011). Common sense risk management of trees: Guidance on trees and public safety in the UK for owners, managers and advisers. The Forestry Commission, Edynburg.
Pachnowska, B. (2021). Aerial tree inspection. Advanced tree assessment – manual for proesionals. Instytut Drzewa, Wroclaw.
Pachnowska, B., Witkoś-Gnach, K. (red.) (2019). Basic and advanced tree assessment - guidelines for training professionals. Dobre Kadry, Centrum badawczo-szkoleniowe, Wroclaw.
Roloff, A. (2015). Handbuch Baumdiagnostik. Baum-Korpersprache and Baum-Beurteilung. Ulmer, Stuttgart.
Roloff, A. (2018). Vitalitätsbeurteilung von Bäumen. Aktueller Stand und Weiterentwicklung. Haymarket Media, Braunschweig.
Tyszko-Chmielowiec, P. (2021). Elementary Tree Biology, Ecology, and Biomechanics. A manual for Tree Assessors and Arborists. Instytut Drzewa, Wrocław.
Watson, G., Green, T. (2011). Fungi on Trees. An Arborists' Field Guide. Arboricultural Association. Stonehouse.
Witkoś-Gnach, K., Krynicki, M. (2021). The tree inspection and diagnostics standard. Fundacja EkoRozwoju, Wroclaw.
Witkoś-Gnach, K., Tyszko-Chmielowiec, P. (red.). (2014). Drzewa w krajobrazie. Podręcznik praktyka. Fundacja Ekorozwoju, Wroclaw.
Witkoś-Gnach, K., Tyszko-Chmielowiec, P. (red.). (2016). Trees – a Lifespan Approach. Contributions to arboriculture from European practitioners. Fundacja Ekorozwoju, Wroclaw.