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Two woodland habitat mapping methods and their applications

In order to protect biodiversity in managed woodland areas, a first step is to obtain information on rare or threatened species as well as important habitats occurring in the area. However, methods of data collection on species and their application in the daily management are very different from those used for habitats.

In general, it is fairly complicated to obtain information on the status of individual species, and the gathering of data that are sufficient for drawing conclusions about management may take years; often the help of experts is required in order to identify and monitor the species in question. Forest managers will frequently find that they have to rely on any accessible information from authorities, experts and amateurs, since a species monitoring programme is often expensive to set up and run.

On the contrary, mapping and monitoring habitats may be done by using relatively simple methods, and the results may often be directly transformed into management recommendations. Habitat mapping and monitoring may be undertaken by the forest's own staff and with a relatively low investment in terms of working hours and money. Efficient protection of biologically valuable habitats is very likely to benefit a large proportion of the sensitive species found in an area, albeit the conservation of some species require different measures.

For these reasons - and without disregarding the importance of species conservation - the scope of this article is limited to habitat mapping. It presents two different methods of mapping valuable habitats in woodland areas:

1. Woodland Key Habitats Inventory

2. Forest Nature Value Assessment

Both of these methods have been developed and adapted to Danish conditions on the basis of similar methods first developed in Sweden (Karlsson *et al* 1995, Lindhe and Drakenberg 1996). These methods have since been adapted to several other countries including Denmark (e.g. Andersson *et al* 1999, Ek *et al* 2000, Hübertz and Pedersen 2000). The guidelines and procedures referred to in this article are Danish versions of the methods (Forest and Nature Agency

Natural woodland streams are among the most unpolluted watercourses in Denmark and therefore often contain sensitive freshwater species. (Photo: Nepenthes).

2000, NEPCon 2000). Both of the methods are simplified in comparison with the Swedish models. The two methods do not cover the same spectrum of habitats and therefore supplement each other in establishing the full picture.

WOODLAND KEY HABITATS INVENTORY

Woodland key habitats are the biological "hotspots" of woodland areas. A woodland key habitat inventory thus aims to identify top quality habitats which are able to satisfy the needs of very sensitive or specialized species. These habitats consist of elements, structures or areas — such as old growth forest, streams, bogs and meadows — where rare or threatened species are likely to be found. All areas of a woodland including the open spaces are covered by the method.

The Danish Forest and Nature Agency defines woodland key habitats as:

Habitats which are important for the conservation of the biological diversity because they contain or are expected to contain habitat types, structures or species, which are having difficulties of surviving conventional forestry and which have special conservation needs in terms of management operations or care (Danish Forest and Nature Agency, 2000).

The Danish method operates with 23 distinct key habitat types (**annex 1**). Furthermore, to help describe and identify key habitats in tree-covered areas it lists 50 specific elements belonging to eight different categories (**annex 2**). Some habitats, such as bogs and natural streams, are almost per definition key habitats and do not require any further justification. For tree-covered habitats, the Danish method suggests that as a rule of thumb a site should contain elements from at least three different categories in order to be classified a key habitat.

FIG.1. WOODLAND KEY HABITATS MAP

Finally, the inventory methodology contains a list of indicator species. These are species of higher plants, mosses, lichens or fungi that strongly suggest a high natural value of the area. Some of the indicator species indicate that a forest area has been continuously covered by trees for many centuries. The use of indicator species is helpful and adds to the quality of the inventory, but it is not a precondition for using the methodology.

Step by step mapping of Woodland Key Habitats. An inventory of Woodland Key Habitats consists of three phases: **1.** Preparatory work, **2.** Field work, and **3.** Data processing.

The preparatory work consists of collecting existing information about the forest before going into the field. In this phase, various sources of information are reviewed to give a hint about where woodland key habitats are located or have been located in the past. The sources of information can be verbal (owners, employees, neighbours, local experts and NGOs) as well as written (old and new maps and management plans, aerial photos, topographical maps, soil maps, botanical, bird and insect surveys and reviews, and former fauna and flora records). All the obtained information is recorded and marked on working maps to be used in the field.

The second phase is the field work. Prior to the field work, the field mappers, equipped with working maps and inventory forms, decide on the route through the forest in order to be able to visit all marked locations found during the first phase. At the same time, as much of the forest area as possible is visited within the time frame available. An inventory form is completed for all locations indicated as either actual or potential woodland key habitats found on the route (**see annex 3**).

Finally, the third phase of processing the field data into digitised information maps and data lists is then undertaken. An important part of this phase is to evaluate the information obtained and to integrate the data into the objectives and aims of the management plans.

The result of the investigation is a digitised map with all actual and potential woodland key habitats marked and an additional data list with specific information on each key habitat (see **figure 1**). Thus, the results of the key habitat inventory are ready for use in the daily management operations, and when management plans and monitoring programmes are prepared or revised.

Limitations of a Woodland Key Habitats Inventory. A Key Habitat Inventory generally only covers a fraction of the total land in question. A woodland area may contain a range of natural values which will not be registered through a Key Habitats Inventory, if they do not qualify as key habitats. But still such values are important to protect and improve, as they are important for the total ability of the woodland area to support biodiversity and to ensure good dispersal possibilities outside of the often very limited spaces which are deemed to be key habitats. Biological corridors, which are not themselves key habitats, may

indeed be crucial for the long-term survival of redlisted species presently found in the key habitats themselves.

Another limitation is inherent in the methodology: Possible key habitats are selected on maps on the basis of available information prior to field visits. The quality of the *a priori* data is thus very important for the completeness of the final inventory.

FOREST NATURE VALUE ASSESSMENT

Nature Value Assessment is another approach which only applies to tree-covered sites, and thus excludes all open areas, such as meadows and heaths. This method aims to assess any stand according to its nature content and to note all elements and structures which support biodiversity even if the stand does not qualify as a key habitat. Thus, detailed information about any specific stand may be obtained by using this method, and recommendations for the conservation and improvement of biodiversity are obtained at stand level. Nature Value Assessment thus leads to information on all the wooded areas which are not key habitats, and thereby supplements the Key Habitat Inventory with valuable additional information.

Nature value assessment aims at mapping biological structures of great importance for biodiversity by calculating a certain score for each individual stand in the forest. The data sheet to be filled in contains 63 questions divided into eight different categories: **1**) general characters, **2**) structure of the stand, **3**) living trees, **4**) epiphytes and ground vegetation, **5**) dying trees and dead wood, **6**) cultural influences, **7**) topography, and **8**) water (see **annex 4**). Each question is worth one point if the structures/elements asked for in the data sheet are present. The total score for a stand may thus vary between 0 and 63.

Step by step Forest Nature Value Assessment

Nature value assessment is carried out at stand level. The assessment consists of three steps in terms of **1**) selecting the stands to be assessed, **2**) assessing the homogeneity of the individual stand, and **3**). filling in the data sheet and counting the points.

HISTORY OF THE DEVELOPMENT OF NATURE VALUE ASSESSMENT

1996: The first method for Nature Value Assessments was developed by the company Skogsbiologerna in Sweden (Lindhe & Drakenberg 1996).
1997: Workshop organized by WWF Sweden and entitled "Assessment of Natural Values at Forest Stand Level" was held in Stockholm, Sweden.
1997: Nepenthes Consult developed the first Danish method for Nature Value Assessment inspired by the Swedish method but adjusted to Danish conditions.
1999-2001: In Estonia, Nature Value Assessments have been applied after adjustment of the method to Estonian conditions. The development took place under the project "Estonian Forest Conservation Area Network" (Estonian-Danish Project 1999-2001).
2000: NEPCon refined the Danish Nature Value Assessment method.
2000: Skogsbiologerna further developed and refined the Swedish method. The refined method is applicable at both stand and landscape level.

The first step is to select the stands that are to be assessed. Most often it is convenient to use the existing delimitation of stands into sub-compartments found on the forest maps, since most managed stands will have a relatively homogeneous aspect. This procedure also eases the production of thematic maps on the basis of the field work. However, it is possible to select other units, and in some cases it may be relevant to merge several sub-compartments or split up one sub-compartment into several units.

The second step is to assess the homogeneity of the individual stand by walking quickly through it. The idea is to get an overview of the features within the stand and not to investigate every part of it. If the chosen stand is very heterogeneous, with several areas of clearly different character, it may be a good idea to assess each of these areas separately.

The third step is to fill in the data sheet. The quick walk through the stand is a precondition for the correct application. The data sheet is filled in by giving a score of 1 for all questions which are answered by "yes". Consequently the points are counted, and the total number of points is an expression of the relative nature value of the stand.

The results of the nature value assessment are often best presented by thematic maps, in which different colours represent different levels of score (**figure 2** provides an example). In many ways such a map can be a planning and prioritisation tool, e.g. if the forest owner wants to let a certain percentage of the forest develop freely. The obtained data can help ensure that existing natural values are conserved during forestry operations. Relevant information about vulnerable biotopes and necessary care can be worked into the the stand tables and marked on forest maps.

Limitations of Forest Nature Value Assessments. Even a full-scale Forest Nature Value Assessment does not provide the full picture of nature values within a woodland area. Firstly, the open spaces and

FIG. 2. EXAMPLE OF NATURE VALUE ASSESSMENT MAP

A stand with a low nature value according to the Nature Value Assessment Inventory.

HISTORY OF WOODLAND KEY HABITATS INVENTORY DEVELOPMENT

1990-91 The firstmethod for inventorying Woodland Key Habitats was developed by the National Forestry Board in Sweden.
1992 Since 1992 the Swedish Forestry Administration has been conducting surveys of woodland key habitats in Sweden.
1994 Nepenthes Consult developed the first Danish method for Woodland Key Haibtats based on the Swedish method but adjusted to Danish conditions.
1999 In Estonia, a methodology of the Woodland Key Habitats Inventory adapted to Estonian conditions was developed on the basis of the Sweidsh model (Andersson, Ek, & Martverk 1999).
1999 The Danish Forest and Nature Agency developed an official Woodland Key Habitats Inventory method for use in Denmark. The development took place as a consultative process, partly on the basis of the earlier developed model.
1997-98 In Latvia, a methodology of Woodland Key Habitats Inventories adapted to Latvian conditions was developed on the basis of the Swedish model (Ek & Auzins 1998, Ek, Susko & Auzins 1998).
2000 Establishment of a Danish subsidy scheme, where Danish private forest owners can apply for subsidies to map their woodland areas by using the Danish official Woodland Key Habitats Inventory Method (› 20 ha).
2000 In Lithuania, the method for registration of Woodland Key Habitats is being adjusted to Lithuanian conditions (in prep.)

water ecosystems such as streams and ponds are not covered by the method as habitats in their own right. Secondly, only the stand level is considered. For instance, some kinds of structural variation of biodiversity importance may exist at a higher level, but may not be obvious at all at the stand level. The landscape level is not currently adressed by the Danish model, but models are being developed in Sweden which also allow analysis at landscape level (Drakenberg 2001). Finally, the lack of focus on plant species makes it impossible to identify special values connected to forest areas that have been continuously wooded for centuries.

RELATIONS BETWEEN THE TWO METHODS

The methods are non-overlapping when open spaces and water ecosystems are concerned, since only the Key Habitats Inventory covers these habitats. But when it comes to tree-covered habitats, some overlap is seen. For instance, wooded sites which score very high in a Nature Value Assessment are almost invariably also deemed to be key habitats in a Key Habitat Inventory.

However, there are some important differences: Nature Value Assessment is not able to discern areas with long forest continuity, whereas a Key Habitat Inventory may do so by using the list of indicator species. It is known that such areas are prone to contain more rare soil-living species, even if the trees are managed rather intensively and the nature value of the site is not apparent in the forest structure. Conversely, many important details on valuable structures and elements of all wooded sites are gained through a Nature Value Assessment, whereas a Key Habitat Inventory only provides such details for a few selected sites.

None of the methods cover biodiversity protection at the landscape level. However, maps produced from the two kinds of inventories do lead to a good overview of the distribution of habitats within a woodland area, which may in turn form the basis for considerations about land use and overall structure of the landscape.

APPLICATIONS

The above methods may be used separately or in conjunction with each other, and they may be carried out as complete surveys of a whole forest estate or just parts of a forest. Below some examples of possible applications are given.

A Key Habitat Inventory provides a good basis for formulating a Nature Conservation Plan. By considering

key habitats the first priority of nature conservation, and carefully responding to their conservation needs through relevant management measures, efficient protection of the most important biotopes of endangered species is ensured.

When applied at full scale, Nature Value Assessments of each stand results in a good overview of the distribution of natural values throughout the tree-covered areas (see figure 2). This overview is valuable, for instance when planning biological corridors or set-aside areas. Furthermore, by incorporating the data and any management recommendations into inventory lists, a Nature Value Assessment becomes a useful nature conservation tool in daily management. Nature Value Assessments may also be used on a stand by stand basis, for example it may be standard procedure to carry out the assessment prior to any forestry operations in a stand. In this way, unnecessary damage to nature values may be avoided.

For a complete overview of the nature values a forest estate, it is highly recommended to perform both an inventory of woodland key habitats and a full-scale nature value assessment. The two methods are easily combined in the field, and by applying both methods the full spectrum of biotopes is covered efficiently. Repeated inventories, for instance in a 5-year cycle, may form part of a biological monitoring programme integrated into the overall forest management plan.

If only one method is applied, it is important to be aware of the limitations of each method.

Also, if the methods are only applied on parts of the land in question, it is necessary to keep in mind that only part of the full picture is known and therefore the background for making wise decisions concerning the overall land use is less optimal.

When the results and the protection needs have been incorporated into the inventory lists and put onto maps, the results of the inventories can be used by the foresters and forest workers in practice. In addition, the data can be used for producing thematic maps indicating high and low nature values of stands as well as the most valuable habitats, for example in terms of GIS layers of biological information. This will provide the nescessary biological overview, which can be used together with GIS layers containing other kinds of information when auditing the overall management plan of the forest. This kind of overview provides a good background for making wise decisions concerning the integration of nature protection with all other aspects of good forest mangement, such as timber production, recreational, cultural and aesthetic values, and game management •

Old and coppiced trees are important key elements in the Danish Key Habitat Inventory system. Such trees also score in the Nature Value Assessment system. (Photo: Nepenthes/Allan Breum Larsen)

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ANNEX I.
LIST OF WOODLAND KEY HABITATS IN THE DANISH INVENTORY SYSTEM

Closed stands	Beech forests with several storeys and dead wood
	Old growth deciduous forests, clearly overmature (near breakdown)
	Continuous forests (with rich ground vegetation including indicator species)
	Deciduous forests with several storeys and dead wood
	Forests (dense forests with lime on old deciduous forest floor)
	Old coniferous forests (› 100 year old conifers with ground vegetation and natural regeneration)
	Grazed forests
	Coppiced forests
	Forest edges (outer and inner edges with several storeys and shrubs)
	Islets (older deciduous islets within coniferous forest)
Scrub	Oak scrub and scrub with other tree species (e.g. birch, hazel, willow or mixtures)
Forest swamps	Alder, Ash, Birch and other wooded swamps (e.g. willow, mixtures, etc.)
Wetlands	Lakes and ponds
	Bogs
	Springs
	Streams (natural or semi-natural)
	Overgrown ditches (old ditches with a natural aspect)
Open environments	Slopes
	Heather stands
	Fringes
	Meadows (old forest meadows with meadow species and +/- grazing/mowing)
Others	Old fences, stone walls, banks and other cultural remains
	Habitats of protected and red listed species

ANNEX 2.
CATEGORIES OF KEY ELEMENTS AND KEY FEATURES USED IN THE DANISH KEY HABITAT INVENTORY METHOD.
DBH = diameter at breast height (1.3m).

CATEGORY	TYPE
Large trees	Old elm *Ulmus* sp. (DBH › 70 cm)
	Old ash *Fraxinus excelsior* (DBH › 70 cm)
	Old European aspen *Populus tremula* (DBH › 70 cm)
	Old beech *Fagus sylvatica* (DBH › 80 cm)
	Old fir/spruce *Picea/Abies* sp. (DBH › 70 cm)
	Old hazel *Corylus avellana* (DBH › 20 cm)
	Old lime *Tilia* sp. (DBH › 40 cm)
	Old *Acer* sp. (D › 60 cm)
	Old oak *Quercus* sp. (DBH › 80 cm)
	Old pine (DBH › 50 cm)
	Old broadleaved spp.
	Old coniferous spp.
Special trees	Tree with bird of prey's nest
	Tree with woodpecker holes
	Dead standing tree
	Coppiced or pollarded tree
	Old solitary spruce in deciduous forest
	Old solitary deciduous tree in coniferous forest
	Old solitary oak with many branches sprouting from the trunk
Stands etc.	Stand with a wildwood aspect
	Stand with several layers
	Forest edge dominated by deciduous trees
	Hedge with shrubs and trees with berries
	Patch of trees (100-1000 m2) which deviate in age or species from the rest of the stand
	Alder *Alnus glutinosa* with stools, diameter of stools › 1 m
Dead wood	Windthrown beech *Fagus sylvatica*
	Windthrown oak *Quercus* sp.
	Windthrown deciduous tree
	Windthrown coniferous tree
	Fallen large branches of deciduous tree (DBH › 20 cm)
	Fallen large branches of coniferous tree (DBH › 20 cm)
	Tall stump (H › 150 cm, DBH › 20 cm)
	Giant stump (DBH › 80 cm)
	Root of windthrown tree which has been uprooted
Breeding localities etc.	Adder locality: Sunny hillside or fence with adders
	Badger's sett
	Fox's den
	Deer wallow
	Very large ant hill (1 m or taller)
Stones and terrain	Large, not very moss-clad blocks of stone (DBH › 1 m)
	Heap of stones , at least 1 cubic metre
	Earthen dike, also with peat, seaweed, gravel and pebbles
Plants	Dense moss vegetation on the forest floor
	Trunks densely overgrown with shrubby lichens
Water	Raised bog
	Small pond, max. 100 m^2 or non-permanent

ANNEX 3. WOODLAND KEY HABITATS FIELD INVENTORY FORM (DENMARK)

Position and type

Habitat type :	Legal protection :	Habitat serial number:
Forest Estate		
Forest Name:	Compartment:	Subcompartment:

Locallity description

Tree species (%, age):	map with notes
Terrain:	
Soil (clay/sand/gravel, nutrient level):	
Humidity conditions:	
Description:	

Key elements

Signal species/ redlisted species

Threat/ Necessary care / Special regards

Classification	Surveyor	Date

ANNEX 4. NATURE VALUE ASSESSMENT (EASTERN DENMARK)

Recorder : _____ Date : _____ Forest : _____ Compartment : _____

1. STAND STRUCTURE AND COMPOSITION
- Native tree species › 25 cm DBH occurs
- Native tree species dominate
- Two or more native tree species › 25 cm DBH occur
- Two or more stand tree species
- Diameters ‹ 20 cm, between 20 and 30 cm and › 30 cm characterize the stand
- Diameters ‹20 cm, between 20 and 80 cm and ›80 cm characterize the stand
- Some trees (at least 5% of the canopy) substantially larger than others
- Several tree stories (›50% of the area)
- Well-developed shrub layer (› 50% of the area)
- Open or with larger holes in the canopy

2. EDGE FEATURES
- Outer edge mainly with native trees and shrubs
- Edge against meadow/heath/bog/fen/common/lake/watercourse

3. LIVING TREES
- Few hardwood trees › 80 cm DBH
- Some hardwood trees › 80 cm DBH
- Many hardwood trees › 80 cm DBH
- Few conifers › 70cm DBH
- Some conifers › 70cm DBH
- Many conifers › 70cm DBH
- Few native *Betula/Alnus/Ulmus/Tilia/Pinus syl/ Prunus avi/Acer pse/Populus* tre › 50 cm DBH
- Some native *Betula/Alnus/Ulmus/Tilia/Pinus syl/ Prunus avi/Acer pse/Populus* tre › 50 cm DBH
- Many native *Betula/Alnus/Ulmus/Tilia/Pinus syl/ Prunus avi/Acer pse/Populus* tre › 50 cm DBH
- Few native *Tilia/Salix/Ulmus/Crataegus/Malus syl/Carpinus bet/Acer cam /Acer pla/Prunus* pad
- Many native *Tilia/Salix/Ulmus/Crataegus/Malus syl/Carpinus bet/Acer cam /Acer pla/Prunus* pad
- Few *Juniperus com/Ribes rub/Ribes nig/Hedera hel/Humulus lup/Ilex aq/Taxus bac/Viburnum* op
- Many *Juniperus com/Ribes rub/Ribes nig/Hedera hel/Humulus lup/Ilex aq/Taxus bac/Viburnum* op
- Tree with nest holes/larger cavities/large bird's nests
- Open grown trees with broad crowns › 40 cm DBH occur

4. EPIPHYTES AND GROUND VEGETATION
- Some cover (› 10%) of shrubby/leafy lichens or mosses on trunks and stones
- Substantial cover (› 40%) of shrubby/leafy lichens or mosses on trunks and stones
- Ground vegetation dominated by broad-leaved herbs/ferns covering › 50% of the area
- Species rich and characteristic ground vegetation or dense moss cover in › 50% of the area
- Open partial area › 100 m2 dominated by grass/heath/herb vegetation

5. DYING TREES AND DEAD WOOD
- Some standing , dead trees/tall stumps
- Some standing, dying or dead trees/tall stumps › 40 cm DBH
- Few standing, dying or dead trees/tall stumps › 80 cm DBH
- Some solitary, sun exposed dying/dead trees/ tall stumps
- Some lying dead trunks/branches › 10 cm DBH
- Few lying dead trunks › 40 cm DBH
- Few lying dead trunks › 80 cm DBH
- Few sun-exposed lying dead trunks › 40 cm DBH
- Dead trunks in varying stages of decay + larger amounts of fallen branches/brushwood
- Moss-covered dead trunks › 40 cm DBH
- Some wind-thrown uprooted trees

6. INFLUENCES
- Many coppiced trees
- Clear signs of former grazing by domestic animals
- Current extensive grazing by domestic animals
- Large stone/stone wall/bank/burial mound
- No signs of soil preparation or vehicle ruts
- No signs of felling

7. TOPOGRAPHY AND SOIL
- Very varied topography
- Steep slope with marked soil erosion
- Poorly drained humid/wet partial area › 100 m2
- Stand dominated by humid/wet soil
- Sun-exposed sand/soil surfaces › 100m2 not or sparsely covered by vegetation

8. WATER
- Periodically flooded or waterlogged area › 100 m2
- Spring
- Brooklet/brook/stream/river
- Naturally winding watercourse
- Pool/pond/lake
- Pool/pond/lake/watercourse/spring in open surroundings
- Pool/pond/lake/watercourse/spring surrounded mostly by broadleaved trees

BIOLOGICAL SCORE:

Guidelines to the field form
All questions answered by "yes" score 1 point. Subsequently the scores are added together. The result is an expression of the relative nature value of the stand.

Native species
The status of Norway spruce Picea abies, Scots pine Pinus sylvestris and sycamore Acer pseudoplatanus in Denmark is debatable. When using the nature value assessment form it is recommended to regard only Scots pine and Sycamore as native.

Stand tree species
A tree species making up at least 10% of the canopy in a stand.

Trees and trunks
One/few: 1-5 trees/trunks per hectare
Some: 5-10 trees/trunks per hectare
Many: ›10 trees/trunks per hectare
Please note that a stand with a high number of the elements in question also scores in the lower categories.

Diameter (DBH)
Diameter measured at breast height (1.3m) or (in the case of high stumps and lying trunks) at the point corresponding most closely to that. When trees have multiple stems, the diameters of each individual stem are added together. Any tree must be at least 10 cm DBH in order to be counted.

Moss and lichen cover
The lowest 100 cm of trunk (closest to the tree base) should be excluded when assessing the cover on trunks.

Ground vegetation

Please notice that quesitons relating to ground vegetation are dependent on time of year. This should be remembered when comparing the nature value score of various stands.

Grazing

Some typical signs are: Open stand, widely spaced trees with broad crowns, thorny shrubs.

Water
An element in the catergory 8 "water" only scores if it is surrounded by the stand on more than one side.

Woody species

Acer cam	Acer campestre
Malus syl	Malus sylvestris
Acer pse	Acer pseudoplatanoides
Pinus syl	Pinus sylvestris
Acer pla	Acer platanoides
Populus tre	Populus tremula
Carpinus bet	Carpinus betulus
Prunus avi	Prunus avium
Corylus ave	Corylus avellana
Prunus pad	Prunus padus
Hedera hel	Hedera helix
Ribes nig	Ribes nigrum
Humulus lup	Humulus lupulus
Ribes rub	Ribes rubrum
Ilex aq	Ilex aquifolium
Taxus bac	Taxus baccata
Juniperus com	Juniperus communis
Viburnum op	Viburnum opulus