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Terhi Ryttäri, Ülle Kukk, Tiiu Kull, Anne Jäkäläniemi and Mari Reitalu (eds.)

Monitoring of threatened vascular plants in Estonia and Finland – methods and experiences

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Foreword

Finland and Estonia began to co-operate on nature conservation in 1991 as part of an agreement made between the governments of both countries on wider co-operation in the field of environmental protection. The two countries subsequently nominated national chairpersons and secretaries for a subsidiary working group for nature conservation, operating under a working group for environmental protection. The nature conservation working group has largely focussed on exchanging experiences related to currently important conservation issues. One vital aspect of this work has been the fraternal exchange of information between expert conservation biologists, and the joint consideration of issues of common scientific interest. Practical short-term projects have already been carried out in connection with many such issues, and the results of this work are already helping to promote nature conservation on both sides of the Gulf of Finland

Monitoring the status of threatened vascular plants and their populations is a very important research area in conservation biology. Vascular plants and their habitat requirements are relatively well understood compared to other species groups, and trends in their populations are good indicators of changes in the state of their habitats. The importance of international co-operation on this subject is widely recognised. The clear geographical links between Finland and Estonia, and the two countries' respective research traditions, with all their similarities and differences, combine to form a good basis for such research co-operation.

This report compiles the results of a joint project started up by Finnish and Estonian botanists in 1995. The publication of this report marks the successful end of an extremely useful phase in the long-term international interaction between scientists in this field, and should also form a good basis for the planning of future joint research. There are many important challenges ahead, and this project has proven how beneficial it is for experts from both countries to remain in close contact.

We would like to take this opportunity to offer our warmest thanks to all of the experts who have been involved in the preparation of this report.

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Introduction

Co-operation in the field of nature conservation between Estonia and Finland started in the early 1990s (Külvik 2001). In 1995, Estonian and Finnish plant conservationists realised that it would be very useful to co-operate more closely on practical projects concerning threatened plants. The theme "*Conservation, monitoring and management of threatened plants in Finland and in Estonia*" was approved by the Estonian-Finnish inter-ministerial nature conservation co-ordinating group, which also financed the related meetings and field excursions, as well as part of the subsequent data analysis. A start-up seminar was held in April 1996, with articles based on the seminar published in Kanerva & Kemppainen (1997). During meetings and field excursions over the period 1997–2002 several issues relating to plant conservation were discussed, including the various methods used to compile Red Data Books and conservation programmes, to carry out inventories, and to monitor and manage plant populations, as well as differences in legislation between the two countries, and the significance of education and public relations. However, one particular issue stood out in importance from all the issues of common interest discussed: the need to improve the monitoring of threatened vascular plants.

Population monitoring is an irreplaceable tool in assessing the need for conservation and management measures to help threatened species, or evaluating the success of such measures. The monitoring of threatened species has recently been closely connected with national commitments under the EU Habitats Directive, and the concept of 'favourable conservation status'. The objectives of monitoring may thus vary considerably. The geographical scale of monitoring may vary from site level to national or even international level. Monitoring work can consume a lot of valuable resources, so it is extremely important that monitoring enables the most crucial questions to be answered.

This report covers the practical aspects of population monitoring in detail. Eight practical examples (case-studies) are examined, so as to assess which aspects of the monitoring methods used are most favourable, and in order to recommend how monitoring can be improved practically in the future. Consideration was also given to the planning of monitoring regimes and the ways data was analysed and stored. The three institutes involved in this project – the Finnish Environment Institute, Metsähallitus (Finnish Forest and Park Service), and the Environmental Protection Institute of the Estonian Agricultural University – are responsible for arranging and carrying out monitoring across the two countries, and are fully aware of the practical problems faced during this work. We hope that this report will make a useful contribution towards improvements in the practicality and cost-efficiency of monitoring.

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3 Why are threatened plants monitored?

The term ‘monitoring’ can cover a wide spectrum of activities. In this paper we define monitoring simply as the repeated collection of data about the populations of threatened plants. Elzinga & al. (2001) have suitably defined the difference between monitoring and research: observational monitoring and scientific research can be seen as the opposite ends of a continuum – in monitoring, results cannot necessarily be statistically inferred; while in research, results can be statistically inferred. Indeed, where the scientific assessment of threatened and rare plants is concerned, there are often huge practical problems in finding enough populations and individuals to conduct statistically valid experiments and studies.

There are many reasons why plant populations should be monitored, and consequently also many perspectives that can be chosen. The highest-level commitment to monitoring is related to the Convention on Biological Diversity, which Estonia and Finland signed along with 155 other countries in Rio de Janeiro in 1992. The obligations in Article 7 are closely related to monitoring: “The Convention on Biological Diversity obliges the Contracting Parties to identify components of biological diversity important for its conservation and sustainable use, monitoring the components of biological diversity through sampling and other techniques, paying particular attention to those requiring urgent conservation measures and those which offer the greatest potential for sustainable use”.

The ideas of the Rio Convention have been incorporated into both national legislation and international agreements. In Europe, the Habitats Directive obliges EU-member countries to monitor and report trends in the conservation status of certain species. Monitoring is also needed to help compile the national and international lists of threatened species, the Red Data Books. These obligations all operate on a greater geographical scale – at national, continental or global level. The lowest levels in the hierarchy of monitoring are the population and subpopulation level. Elzinga & al. (2001) strongly emphasise the importance of monitoring connected to management activities. In practice, a single population may be the focus of monitoring on all these levels. Here we shall briefly discuss the various kinds of monitoring data needed for different purposes.

A. Monitoring connected with the preparation of Red Data Books

In compiling national and international lists of threatened species, the use of the classification and criteria launched by IUCN (IUCN 2001) is becoming more common, and is highly recommended. The successful application of these criteria, however, requires a lot more in terms of the quality of the information than before. Another significant factor is that very many species and populations should be assessed according to these criteria, including taxa which are not threatened.

All of the five criteria (A–E) defined by the IUCN (IUCN 2001) require either population or distribution data. To apply *criterion A,* at least an estimate of population decline is required. This can be based on either direct observations, an index of abundance, or even on an observed decline in the area of occupancy or the quality of habitat. To use *criterion B,* the extent of occurrence should be known, along with the degree of fragmentation, population fluctuations and/or decline in the area of occupancy, the area and quality of habitat, and the number of locations, sub-populations and mature individuals. The use of both criteria A and B probably allows most freedom of action, and does not require exact quantitative data on the populations.

The use of *criterion C* requires that reasonably accurate long-term monitoring data on the trends in numbers of mature individuals is already available. Such data may be available for certain populations, but rarely for all populations within a country. This seriously hampers generalisations, especially if only either the thriving populations or the declining populations have been included in monitoring.

Applying *criterion D* requires data on population sizes measured in terms of the number of mature individuals. Finally, *criterion E* is based on a quantitative analysis, which the IUCN (2001) define as any form of analysis which estimates the extinction probability of a taxon based on its known life history, habitat requirements, threats and any specified management options.

To conclude: the application of IUCN criteria presumes that monitoring data is available on trends in the numbers of populations and/or mature individuals, the distribution of the species, and the amount and quality of its habitat. Applying these criteria does not necessarily require data on other stages of the lifecycle than mature individuals. This simplifies monitoring considerably, as it is not necessary to search for vegetative and juvenile stages.

B. Monitoring and the EU Habitats Directive

The council of the European Communities adopted in 1992 the Council Directive (92/43/EEC) on the conservation of natural habitats and of wild fauna and flora, referred to in this report as the EU Habitats Directive. The European Community has listed important plant and animal species and habitat types whose survival has to be ensured, by for example establishing nature reserves within the Natura 2000 -network. These species and habitat types are listed in the Annexes I (habitat types) and II (species) of the Habitats Directive. A central concept in the Habitats Directive is "favourable conservation status". The conservation status of a species means the sum of the influences acting on the species concerned that may affect the long-term distribution and abundance of its populations within the territory referred to in Article 2.

The conservation status of a species will be taken as "favourable" when:

- population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats
- the natural range of the species is neither being reduced, nor is likely to be reduced for the foreseeable future, and
- there is, and will probably continue to be, a sufficiently large area of habitat to maintain its populations on a long-term basis

According to Article 11, Member States shall undertake surveillance of the conservation status of the natural habitats and species referred to in Article 2 with particular regard to priority natural habitat types and priority species. Furthermore, Article 17 states that Member States shall draw up a report to the Commission about the results of this surveillance every six years. The EU has not yet given detailed instructions about the enforcement and standard of monitoring. The first reporting period as specified in Article 17 covered the years 1994–2000, but no results or plans for monitoring were required for the report concerning this period. The next report will be published in 2007.

The monitoring required under the Habitats Directive can be based on monitoring the elements of favourable conservation status described above. "Population dynamics data" should include information on population trends and recruitment success rates for a representative sample of populations. In assessing the development of the natural range of the species, at least presence/absence data for a representative sample of populations situated both in the centre and the edges of the distribution area must be included. Furthermore, developments in the quality and area of the habitat should also be included in monitoring. Monitoring requirements within the Habitats Directive are discussed in more detail below, in the case study *Cypripedium calceolus* (p. 76).

C. Monitoring connected with management and restoration

The scope of this type of monitoring may be focused on a single population or site. In such cases, monitoring should always be related to all the management and restoration activities being carried out with regard to the populations of threatened plants. Without monitoring, it is not possible to assess the success or failure of such management work. A population which is to be the focus of planned management measures should be carefully inventored before any management activities commence.

Definitions

In this publication we shall use two terms for monitoring to describe the varying accuracy of methods. The term *plot monitoring* will be used to mean a monitoring practice where permanent plots are repeatedly surveyed to provide area-related data. The exact locations of these populations are thus fixed and well-known, and monitoring can be done after flowering, so that seed and/or capsule production can also be recorded. The term *status monitoring* will be used for a more lighter monitoring regime, where no permanent plots are in use, but rather the aim is to estimate the whole population size or simply to record whether the population still exists or not. Status monitoring can be timed to coincide with flowering, when plants are easiest to find. For status monitoring, Estonian and Finnish researchers have each designed their own data-collection sheets, which are presented in chapters 4 and 5.

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Monitoring of vascular plants in Estonia

4

Ülle Kukk

4.1 Introduction

In Estonia, the surveying of rare plants started in 1970, when it became obvious that building and other activities had significantly changed Estonia's landscape and vegetation. In those days, there was little up-to-date information about the situation in localities where rare plants were growing, about how many plants were preserved, or about what could be done to protect them. In 1976, the Institute of Forestry and Nature Conservation initiated a large-scale survey of rare and threatened plants, and this work continued until 1993. Later, such inventories could only be conducted under regional applied research projects.

In 1994, the government-supported National Environmental Monitoring Programme of Estonia was launched. The Natural Biodiversity Monitoring Sub-programme (before 1999 known as the Species and Communities Programme) forms a part of this major programme, and since 1994 the monitoring of threatened plants has been conducted within this framework.

The Natural Biodiversity Monitoring Sub-programme takes into account Estonia's international obligations regarding the maintenance of Biodiversity (92/43 EEC, 79/409 Bern Convention, BD Convention, IUCN, EEC, EIONET, Natura 2000), as well as the national need for information (the Act on Protected Natural Objects, and the Estonian Red List) (Kull 1999, Klein 2000). The sub-programme includes 44 separate projects, in the following fields:

- Landscape monitoring (coasts, and natural and cultural landscapes): 3 projects
- Monitoring of plant communities: 9 projects
- Monitoring of communities of birds, insects, fungi, etc.: 11 projects
- Monitoring of animal species: 16 projects
- Monitoring of lichen species: 1 project
- Monitoring of bryophyte species: 2 projects
- Monitoring of vascular plant species: 2 projects (protected and threatened plants).

The biodiversity monitoring sub-programme has been arranged through government purchases. The Environmental Protection Institute co-ordinates the work of whole sub-programme, and is principally responsible for the implementation of some projects, including the monitoring of vascular plants and plant communities. Botanists from seven institutions are engaged in this work: the Environmental Protection Institute, the Institute of Zoology and Botany, Tartu University, the Estonian Natural History Museum, Tallinn Botanical Gardens, Viidumäe Nature Reserve, and Hiiumaa Island.

Some 1,538 vascular plant species can currently be found in Estonia (T. Kukk, 1999), with 193 of these species legally protected under the 1994 Act on Protected Natural Objects (additions in 2001 and 2003). Protected plant species are classified into three categories: Category I includes 23 species; Category II, 123 species;

and Category III, 47 species. The plants in Category I are of great scientific value (relics, species with a limited distribution, or species occurring at the extremities of their range), and are very rare or directly threatened. Category II also includes scientifically valuable species, but these species are not so threatened as the Category I species, so protected areas need not be designated for all their habitats. Category III includes species which although not so rare, are threatened for various reasons, such as habitat destruction or their use for decorative or medicinal purposes, or as food (Ü. Kukk 1999).

The most recent volume of the Estonian Red Data Book (RDB) (Lilleleht 1998) lists a total of 309 vascular plants as threatened, under the following categories: Category 0 (Extinct or probably extinct), 27 species; Category 1 (Endangered), 31 species; Category 2 (Vulnerable), 29 species; Category 3 (Rare), 100 species; Category 4 (Care demanding), 54 species; Category 5 (Indeterminate), 68 species. The list of protected plants and the red list do not entirely coincide, since the list of protected plants includes a number of plants protected due to their decorative or medicinal uses, which are not included in the RDB; while it does not include species thought to be extinct in Estonia, or those included in Category 5 (Indeterminate status) in the RDB.

Fourteen species that grow in Estonia are listed in the EU Habitats Directive Annex II: *Agrimonia pilosa, Angelica palustris, (Botrychium simplex,* extinct*), Cinna latifolia, Cypripedium calceolus, Dianthus arenarius* subsp. *arenarius, Ligularia sibirica, Liparis loeselii, Moehringia lateriflora, Najas flexilis, Pulsatilla patens, Saxifraga hirculus, Sisymbrium supinum,* and *Thesium ebracteatum* (two other sub-species proposed for listing are *Rhinanthus rumelicus* subsp. *osiliensis,* and *Saussurea alpina* subsp. *esthonica*).

The Bern Convention Appendix I includes 13 species of vascular plants found in Estonia, and one species now considered to be extinct: *Angelica palustris, Botrychium simplex (*extinct*), Botrychium multifidum, Botrychium matricariifolium, Cypripedium calceolus, Dracocephalum ruyschiana, Ligularia sibirica, Liparis loeselii, Najas flexilis, Pulsatilla patens, Saxifraga hirculus, Sisymbrium supinum,* and *Thesium ebracteatum.*

4.2 The vascular plant species monitoring project

The aim of monitoring is to obtain up-to-date information about the state of populations of threatened and protected plants in Estonia, and about changes in their structure and growth conditions.

The objectives of monitoring and the principles used to select species for monitoring have changed over time, according to both levels of knowledge and national needs. Several approaches have been proposed with regard to launching new monitoring regimes. One idea is to start with the monitoring of the numerous species that are threatened in Estonia, by collecting data about their populations, as well as about species that are only surveyed with a longer monitoring interval (known as country level monitoring). Another approach would consist of a more detailed population study of a few species, examined several times a year for 2–3 years (population level monitoring). The first approach, i.e. monitoring a large number of species, has so far been applied to obtain information about current trends before any decision to either continue with more detailed monitoring, or introduce some kind of management to improve each plant's prospects as necessary. Especially during the early years of this work, researchers had to take into account the proposals of various authorities when selecting plant species and sites for monitoring, as well as the primary considerations of the rarity of each species and the degree of threat.

The first priority species groups were:

- Extremely rare and endangered plant species found in only 1–5 localities in Estonia, listed in the Red Data Book categories 1, 2 and partly 3 (to be monitored at all sites). More than 60 species currently occur in fewer than 5 localities in Estonia.
- The 23 plant species protected in Category I (requiring the strictest protection; to be monitored in at least 3 sites).
- Plant species protected by international conventions and the Habitats Directive (18 species).
- Species associated with transitional land use conditions and habitats.
- Species used as indicators of a particular vegetation community or ecosystem (Kukk, 2000).

These species are all listed in Appendix 1, with their respective Red Data Book status and protection category.

Monitoring is intended to provide information about:

- Trends in population sizes and their viability
- Trends in plant habitats
- The reasons behind changes in plant populations and their habitats
- The biology of each species (population structure, sexual and vegetative reproduction).

The results of the monitoring of very rare or endangered plant species are especially valuable, because they provide direct information about the state of these plants both at the national and the population level. Each monitoring round establishes the situation for a particular year. Subsequent monitoring rounds will then provide additional information concerning the biology and conservation requirements for monitored plant species.

4.2.1 Monitoring methods

Monitoring of vascular plants started in 1994 according to the method known as plot monitoring. The decision to start with national monitoring was only made a few months before fieldwork commenced, so there was little time to work out methods in detail, and several issues remained unclear. The methods adopted have subsequently been improved according to new ideas, and considering the mistakes made during the early practical work. In 1998, Estonia's Species and Communities Monitoring Sub-programme (later renamed Biodiversity Monitoring) was analysed by a group of international experts. The monitoring project on vascular plants was evaluated by the Swedish botanist Mora Aronsson. Many different ideas were discussed, and some proposals were regarded as suitable for implementation in Estonia. The general outline of the plot monitoring method was approved, while a new method known as the status monitoring method was also proposed. Since 1999, both the plot monitoring and the status monitoring methods have been used. Status monitoring is useful in that it requires less time, and provides an opportunity to obtain information about a larger number of sites.

Plot monitoring

General guidelines have been drawn up for plot monitoring fieldwork as follows:

- Monitoring sites should be permanent.
- Plot sizes should depend on the type of plant. A 10 m x 10 m plot is generally recommended for herbs, and 50 m x 50 m or 10 m x 250 m plots for shrubs and trees (not previously monitored).
- The shape of the plot should depend on the extent of a population, relief, vegetation cover, etc.
- The best time to carry out fieldwork where a habitat can only be studied once a year is usually the flowering season, or the period between flowering and fruiting, although this may be not sufficient in some cases. According to the biology of the species, another monitoring survey may be needed before or after the flowering period.
- Monitoring sites and plots should be carefully marked both in the field and on maps.

Monitoring intervals of 1–3 years are suitable for very rare and endangered species (in some cases annual monitoring may be necessary); 3 consecutive years followed by an interval of 3 or 5 years for orchids, annuals and biennials; and 5 years for other perennials. For some species the interval may be even longer.

The description parameters provide information on the monitoring site, the habitat, the population, and other species on the monitoring plot. A special sheet has been drawn up for registering this data (published in Kukk, 1997).

Monitoring site. The following data should be specified: the landowner, the name of the village and community, the county or forest district, an the compartment and sub-compartment. Landmarks such as signs, houses and roads should be mentioned to help surveyors locate the site on subsequent monitoring visits.

Habitat descriptions should include the following information:

Vegetation type. A special survey “Classification of Estonian vegetation site types”, compiled by Jaanus Paal, was published in 1997. This study attempts to unify previous classifications and harmonise them with international classifications. A practical manual has been published for use in all inventories, and this is also recommended for use in species monitoring.

A list of associated species, with estimates of their abundance on a 5-point scale, is essential. This can help to explain any changes that have taken place in the monitored population. All threatened and protected species observed at the monitoring site should also be recorded.

The growth conditions entry should include information about the water-regime, the light-to-shade relationship and soil properties. These estimates should be made on the basis of the individual surveyor’s judgement and knowledge.

Any nearby human settlement should be characterised to help assess the degree of human impact.

Populations or sub-populations should be described in general: the total extent of the population, the total number of specimens (when possible), coverage and status in the community.

The monitoring plot is the area where most measurements and investigations are performed.

1. All specimens should be counted. In some cases the number of tussocks (or shoots) has been counted, but this is not always possible or even necessary, depending on the type of species, and on how many specimens can be found on the plot. If very many individuals are present (hundreds), specimens should be counted and measured in a smaller area of a few (5–10)

square metres. Counting and measuring all specimens in high density populations, may result damage to the whole community by trampling.
2. The heights of adult flowering plants should be measured. This can involve measuring all the flowering shoots or merely the longest flowering shoot of a single tussock, as long as this is done consistently for each species.
3. Classification into different growth stages, i.e. the number of generative adults, vegetative adults and juvenile plants.
4. Coverage should be given separately in percentage terms for the herb and the moss (lichens) layer. All specimens of shrubs and trees should be counted, with estimates for their heights and the density of the canopy (in forest).
5. Abundance on a 5-point scale should be estimated, especially when counting all specimens is impossible due to their large number.
6. Viability of the population on a 3-point scale: viable, normal, weak.
7. Any signs of disease or damage should be recorded. The factors responsible for any damage have not previously been assessed, although this would be necessary in future.
8. If any human impact is noticeable, its type and degree should be described.

Different practices have been used in measuring the locations of plants on the plot for perennials. In the first years of monitoring all specimens were mapped, but this proved to be problematic (with regard to defining individuals, precision, comparability of data, etc.) and this procedure has been abandoned.

Status monitoring

Status monitoring was taken into use for less threatened species, and locations where plot monitoring was not performed. In status monitoring, the size, general situation and threat factors of the population are estimated, as well the approximate ratio of generative to vegetative specimens. The main advantage here is the opportunity to obtain more information on a larger scale. The status monitoring form is presented in Appendix 2 below.

Maps

The UTM grid system is used to get a better overview of the location of the monitoring sites. Quadrates of 10 x 10 km are used within larger 50 x 50 km quadrates. Monitoring sites should be marked on 1:10 000 maps, accompanied by geographical co-ordinates. When a population is sufficiently large, its extent should be drawn separately on the same map, or on a separate high-resolution scheme (e.g. 1:100 in the case of herbs). For trees and shrubs the scale should be smaller.

4.2.2 Review of the vascular plant monitoring project

The vascular plant monitoring project currently includes 153 species in 603 monitoring sites, some of which have been monitored by both plot monitoring and status monitoring. The species selection has been explained in chapter 4.2. The 42 species monitored by plot monitoring only are generally very rare and have only few localities in Estonia. 68 species monitored both by plot monitoring and status monitoring have a higher number of localities. As the possibilities to use plot monitoring only are limited, both methods are in use. Every year a small number of new species and new monitoring sites are added, so these numbers are not definitive.

Altogether 110 species are presently monitored by the plot method, at 216 sites. The complete destruction of habitat has been recorded at one or two monitoring sites every year. In future it may be necessary to create new monitoring plots. The success of the plan will depend on the resources allocated by the State, and on the availability and initiative of botanists. About 20 botanists have so far been involved in the project.

The status monitoring method is currently used to monitor 112 species, at 387 monitoring sites. 43 species monitored by status monitoring only are usually rather widely distributed and belong to the protection categories II and III. The selection of species for monitoring is still somewhat random, and largely depends on the availability and interest of botanist surveyors.

It is still too early to make conclusions about the general state of the majority of the monitored species. Monitoring populations once or twice is not sufficient to enable an accurate estimation of their status. Monitoring results are more reliable when the number of localities involved is small, when sites are monitored several times, and when the direction of any trend is clearly evident. In cases where there are dozens of sites, and it has only been possible to monitor a few of them, the results can be interpreted more reliably when the monitored sites are ecologically different and located as far as possible from each other.

Where the status of a threatened species seems to have improved, various factors could be behind the observed trend: suitable habitats may have been more thoroughly surveyed than previously; protection measures may have been successfully implemented; or new areas of habitat may have been colonised, for instance. The populations of a few dozen species are thought to be increasing, including the following examples: *Radiola linoides* has increased due to the management measures applied in its habitat. *Cruciata laevipes* and *C. cruciata* are only now starting to be studied in detail in Estonia, and some occurrences of *C. laevipes* have only been found recently. The population of *C. cruciata* has evidently expanded over the last five years, but there is no earlier data for comparison. In the case of *Dactylorhiza baltica, Botrychium matricariifolium* and *B. multifidum*, local populations have not significantly increased, but several previously unknown occurrences of *B. multifidum* have been found recently, thanks to the work of a specialist interested in *Botrychium*. This indicates that the general situation for this species is not as poor as had been speculated. *Oxytropis sordida* and *Serratula tinctoria* also show signs of expansion; but this may only be a temporary phenomenon. This is because both species benefit from moderate human activity, and if their new habitats gradually become overgrown with shrubs and trees, reducing the availability of light, their numbers and vitality could soon decline again.

The number of species whose situation has obviously deteriorated is more than twice as large as the number of species whose populations have improved. These declining species are associated with the following habitat types: forests (*Ranunculus lanuginosus, Epipogium aphyllum, Arenaria stenophylla, Astragalus arenarius*); meadows (*Orchis (Neotinea) ustulata, Orchis morio, Gladiolus imbricatus, Coeloglossum viride, Cephalanthera rubra, Cephalanthera longifolia, Anacamptis pyramidalis, Aconitum lasiostomum, Equisetum scirpoides*); mires (*Rubus arcticus, Lycopodiella inundata, Ligularia sibirica, Juncus squarrosus, Crepis mollis*); and alvars and cliffs (*Poa alpina, Cerastium alpinum* subsp. *lanatum, Dactylorhiza sambucina, Asplenium septentrionale*).

During the nine-year monitoring period the situation has worsened critically for the populations of *Aconitum lasiostomum, Cerastium alpinum* subsp. *lanatum, Coeloglossum viride, Equisetum scirpoides, Dactylorhiza sambucina. Lathyrus linifolius* and *Woodsia ilvensis* have disappeared from all the localities where they previously occurred.

The reasons for the decline and extinction of plant species may differ considerably, and are often hard to define, but it is thought that changing ecological conditions have been decisive at least in the following cases:

1. Clear cutting has destroyed populations of *Ranunculus lanuginosus* and *Epipogium aphyllum. Arenaria stenophylla* and *Astragalus arenarius* are easily damaged by inappropriate forestry methods and machinery. These species prefer open ground and cannot survive where mosses grow intensively.
2. Meadow, mire and alvar plants have declined where their habitats are no longer mown or grazed, and have become overgrown with shrubs and trees.
3. Mechanical damage to cliffs and old limestone walls has led to the decline of their characteristic plants.
4. *Dactylorhiza sambucina* was only reintroduced into Estonia from Åland in 1989. Since this time the condition of plants has gradually worsened, and it seems that the reintroduction has failed. There may also be natural biological causes behind these problems.

A total of 90 threatened or protected plant species have not yet been monitored in Estonia, for the following reasons: species only recently discovered in Estonia; lack of information about exact localities; lack of finances or interest for monitoring; trees, shrubs, weeds and aquatic and coastal plants whose monitoring would require special methods; species that are currently so widespread in Estonia that there is no need for monitoring and species excluded from the monitoring programme due to their extinction in Estonia.

Usually, a combination of factors is involved wherever monitoring has not been started. If more resources become available – following the termination of monitoring of several other species, for instance – then the monitoring of new species groups should be launched. Special surveys may even be worthwhile to search for some species currently listed in Category 0 (extinct) in the Red List. With two rounds of monitoring to be completed during 2003, this is an opportune time for the whole programme to be examined, with assessments made for each species to find out which monitoring methods should be adopted, or indeed whether there is any need for further monitoring at all. There is also a need for data formatting to be further developed.

4.3 Plant species listed in the EU Habitats Directive Annex II found in Estonia

Merit Otsus

Annex II of the EU Habitats Directive includes 14 vascular plant species and 6 bryophyte species found in Estonia. A further three Annex II species – *Botrychium simplex*, *Najas flexilis* and *Meesia longiseta* – have not been found in Estonia for at least 10 years. This means that Sites of the Community Interest (SCIs) can be designated in Estonia for any of the 20 listed species (Table 1.). Two endemic species – *Saussurea alpina ssp. esthonica* and *R. osiliensis* – have been added to Annex II according to a proposal made by Estonia.

In the first stage of site selection, existing data about the distribution of the listed species and the state of their local populations in Estonia was revised. The main preparatory work was done within the framework of a joint project involving the Estonian Fund for Nature, and Danish Cooperation for Environment in Eastern Europe, DANCEE: "National Inventories of Internationally Important

Species and habitats in relation to International Conventions and Directives, 1998–2000". Data from all possible sources, including herbaria, the databases of universities and botanical gardens, the results of national monitoring programmes for plant species, published articles, and the knowledge and experience of experts, was compiled in order to get a comprehensive overview of the situation, and to see where there may be gaps in the data. The project originally aimed to list the 10 best sites for each species, but this was only achieved for *C. calceolus, Liparis loeselii, Saussurea alpina* ssp. *esthonica*, and *Hamatocaulis vernicosus.* In several cases where only a few sites could be defined, this merely indicated the lack of reliable data, but in some cases it reflects the actual situation in terms of the rarity of the species in Estonia. In some cases, less attention had previously been paid to species which did not have protected status nationally. In general, the data on the current distribution and abundance of species was insufficient for most species. This indicates that a lot of fieldwork must be carried out before sites are selected for the Natura 2000 network proposals.

Using the results of the monitoring project, as well as their own data, the botanists involved systematically visited the growth sites of the plants concerned, according to the EC criteria for the selection of Natura sites, as presented in Annex III of the Habitats Directive, and the rough guidelines to cover 20–60% of the national population of each species. Special data sheets were filled in for every site surveyed for possible inclusion in the Natura network, and these sheets provide all the information needed for the Natura 2000 standard data forms. This fieldwork resulted in proposals for Natura 2000 sites, as referred to in Table 1. The fieldwork data was also recorded on paper maps showing growth sites, and in many cases also the proposed boundaries for potential Natura sites.

The habitats listed in the Habitats Directive Annex I were also surveyed in 2001 and 2002. If any Annex II plant species were found during these inventories, similar data sheets were filled in, including estimations of the abundance of the plant and the situation of its habitat. This provided some valuable complementary data on threatened plants.

All the field data was subsequently digitalised. When added to species data from earlier inventories of wetlands and semi-natural communities (in the form of information tables and map layers), and distribution data on protected species collected for the Estonian Nature Infosystem, the picture became quite comprehensive.

The number of sites proposed by species experts for designation as Natura SCIs may at first sight seem to be low. This is because so far only the most abundant and representative populations that make up a significant proportion of total Estonian population have been included, and the figures in the Table 1 do not include the all the populations surveyed. In the case of *Cypripedium calceolus*, for instance, large populations were included first, before populations which despite having fewer individuals are nevertheless significant from a geographical distribution point of view. A lot of valuable information was collected during the related fieldwork. New and more exact information about growth sites and distribution now exists for these species, to support the final Natura 2000 site selection.

In 1994, when the national biodiversity monitoring programme started, several plant species listed in the EU Habitats Directive Annex II were initially left out (including *Agrimonia pilosa, Angelica palustris, Cinna latifolia*, *Dianthus arenarius* ssp. *arenarius, Sisymbrium supinum*), andthese species were only later added to the list of species to be monitored. Five more species – *Agrimonia pilosa*, *Angelica palustris*, *Dianthus arnearius* ssp. *arenarius, Sisymbrium supinum, Thesium ebracteatum* – were only protected in Estonia in 2003, so at the beginning of the site selection process they had no legal protection.

At Natura 2000 sites, the surveillance of the status of species can be conducted jointly with the surveillance of habitat types. The EU has not yet provided specific guidelines for conducting the surveillance of Natura 2000 sites. The present level of surveillance for the species within the framework of the national monitoring programme can at present be considered to give suitable and sufficient knowledge about the conservation status of species in Natura 2000 sites. So far, two methods have been used to monitor the status of species: plot monitoring and status monitoring. The type and frequency of monitoring must be based on the number of local populations of the species, and its biology and ecology. More sites should be included in the case of Annex II species, but in these additional sites the faster method – status monitoring – could be sufficient for several species. Estimates of population sizes, vitality, the condition of the habitat, potential hazards or negative changes in the habitat, all give useful information about the general trends affecting the species in the site concerned. Where a species only has very few populations, all sites should be under persistent surveillance.

Table 1. Estonian vascular plant species listed in the Habitats Directive Annex II.

Species	No. of sites proposed as SCIs
Agrimonia pilosa	8
Angelica palustris	12
Cinna latifolia	11
Cypripedium calceolus	13
Dianthus arenarius ssp. arenarius	7
Ligularia sibirica	8
Liparis loeselii	12
Moehringia lateriflora	1
Najas flexilis	0
Pulsatilla patens	6
Rhinanthus osilisensis	10
Saussurea alpina ssp. esthonica	30
Saxifraga hirculus	9
Sisymbrium supinum	7
Thesium ebracteatum	7

4.4 References

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Appendix 1. Plant species monitored in Estonia (1994–2002)

Key

Threat and protection statuses are shown below as follows:
Red List Category – Arabic numeral;
Protection Category – Roman numeral;
Bern Convention listing – B;
Listing in EU Directives – N

Species	Threat and protection status	No. of plot monitoring sites	No. of cases of plot monitoring per plot	No. of status monitoring sites
1. *Aconitum lasiostomum*	**1, I**	1	3	
2. *Agrimonia pilosa*	**III, N**	2	1,1	5
3. *Agrostemma githago*	**1**			1
4. *Ajuga pyramidalis*	**2, I**	2	4,3	
5. *Ajuga reptans*	**1,II**	1	2	1
6. *Allium vineale*	**3,II**	2	2,1	1
7. *Alyssum gmelinii*	**3,II**	1	2	
8. *x Ammocalamagrostis baltica*	**3**			1
9. *Anacamptis pyramidalis*	**2,II**	2	5,3	4
10. *Angelica palustris*	**4, III, B, N**	1	1	3
11. *Arctium nemorosum*	**1**	1	3	
12. *Arenaria procera*	**2, II**	3	2,2,1	
13. *Artemisia maritima*	**3, II**			1
14. *Asplenium ruta-muraria*	**2, II**	2	2,3	6
15. *Asplenium septentrionale*	**3, I**	1	5	
16. *Asplenium trichomanes*	**3, II**	2	2,1	10
17. *Astragalus arenarius*	**2, II**	1	4	
18. *Botrychium matricariifolium*	**1, I, B**	2	4,3	1
19. *Botrychium multifidum*	**1, II, B**	1	1	3
20. *Botrychium virginianum*	**5**			2
21. *Bromus benekenii*	**3, II**	1	2	3
22. *Bupleurum tenuissimum*	**3, II**			1
23. *Cardamine hirsuta*	**3, II**			3
24. *Carex extensa*	**4, II**			3
25. *Carex glareosa*	**3, II**			1
26. *Carex mackenziei*	**3, II**	2	1,1	
27. *Carex rhizina*	**2, I**	3	3,3,1	
28. *Centunculus minimus*	**3**			1
29. *Cephalanthera longifolia*	**3, II**	3	5,5,5	2
30. *Cephalanthera rubra*	**3, II**	3	4,4,5	2
31. *Cerastium alpinum*	**1, I**	1	9	
32. *Cerastium pumilum*	**3, II**	1	3	
33. *Cinna latifolia*	**3, II, N**	1	1	
34. *Cladium mariscus*	**4, II**			5
35. *Cochlearia danica*	**3, II**	1	4	

Species	Threat and protection status	No. of plot monitoring sites	No. of cases of plot monitoring per plot	No. of status monitoring sites
36. Coeloglossum viride	**1, II**	3	7,3,5	3
37. Colchicum autumnale	**III**			4
38. Corallorhiza trifida	**3, II**			2
39. Corydalis intermedia	**3, II**	1	2	2
40. Crepis mollis	**2, II**	1	1	
41. Cruciata glabra	**2, II**	1	2	1
42. Cruciata laevipes	**3**			1
43. Cypripedium calceolus	**4, II, B, N**	6	3,5,4,2,5,6	8
44. Cystopteris sudetica	**3, I**	1	3	
45. Dactylorhiza baltica	**4, II**	3	3,3,3	13
46. Dactylorhiza cruenta	**3, II**	3	4,3,3	3
47. Dactylorhiza fuchsii	**III**			2
48. Dactylorhiza incarnata	**III**	1	3	3
49. Dactylorhiza maculata	**III**			1
50. Dactylorhiza praetermissa	**1, I**	1	5	
51. Dactylorhiza russowii	**4, II**	1	3	10
52. Dactylorhiza ruthei	**1, I**	1	9	
53. Dactylorhiza sambucina	**1, I**	1	9	1
54. Dianthus arenarius	**III, N**	2	1,1	7
55. Dianthus superbus	**4, II**			6
56. Draba muralis	**3, II**	2	3,2	
57. Dracocephalum ruyschiana	**3, II, B**			4
58. Epipactis atrorubens	**III**	1	2	3
59. Epipactis helleborine	**III**	1	3	11
60. Epipactis palustris	**III**	1	3	4
61. Epipogium aphyllum	**1, I,**	2	7,9	1
62. Equisetum scirpoides	**1, II**	1	1	
63. Equisetum trachyodon	**3, I**	1	3	
64. Equisetum x moorei	**2, II**	3	2,1,1	
65. Eryngium maritimum	**3, II**	3	2,2,2	8
66. Festuca altissima	**3, II**	1	2	1
67. Geranium columbinum	**0**			2
68. Geranium lucidum	**3, II**			1
69. Gladiolus imbricatus	**4, III**	2	2,2	4
70. Goodyera repens	**III**			2
71. Gymnadenia conopsea	**III**			3
72. Gymnadenia odoratissima	**3, II**	3	5,5,5	2
73. Gymnocarpium robertianum	**4, II**	2	1,1,2	12
74. Halimione pedunculata	**3, II**	2	1,4	1
75. Hammarbya paludosa	**3, II**	1	3	3
76. Hedera helix	**3, II**	3	2,2,2	1
77. Helichrysum arenarium	**4, II**	2	2,2	6
78. Herminium monorchis	**4, II**			13
79. Holcus mollis	**5, II**			1
80. Hornungia petraea	**3, II**	1	3	

Species	Threat and protection status	No. of plot monitoring sites	No. of cases of plot monitoring per plot	No. of status monitoring sites
81. Huperzia selago	**III**			3
82. Hydrocotyle vulgaris	**3, II**			5
83. Hypericum montanum	**3, II**	2	1,1	3
84. Iris sibirica	**4, III**			4
85. Jovibarba globifera	**4, III**	2	2,2	2
86. Juncus squarrosus	**1, II**	3	2,2,3	
87. Lathyrus niger	**3, II**			1
88. Lepidium latifolium	**4**			1
89. Ligularia sibirica	**2, I, B, N**	5	7,3,5,4,4	3
90. Liparis loeselii	**3, II, B, N**	3	5,5,5	20
91. Listera cordata	**4, II**	3	5,5,5	6
92. Listera ovata	**III**			1
93. Littorella uniflora	**2, I**	2	3,1	(1)
94. Lunaria rediviva	**4, III**			3
95. Lycopodiella inundata	**2, II**	1	2	3
96. Malaxis monophyllos	**3, II**	3	4,5,3	3
97. Moehringia lateriflora	**1, II, N**	1	2	
98. Mulgedium sibiricum	**3, II**	1	2	2
99. Neottia nidus-avis	**III**			3
100. Nuphar pumila	**2, II**			2
101. Onobrychis arenaria	**3, II**	2	2,2	1
102. Ophrys insectifera	**4, II**	3	4,5,1	7
103. Orchis mascula	**4, II**	4	3,5,5,5	1
104. Orchis militaris	**4, III**			1
105. Orchis morio	**3, II**	3	5,5,5	
106. Orchis ustulata	**4, II**	5	4,6,7,5,1	5
107. Orobanche bartlingii	**4**	1	3	
108. Orobanche pallidiflora	**4**	1	2	
109. Oxytropis sordida	**3, I**	1	3	
110. Oxytropis pilosa	**3, II**	3	2,2,2	5
111. Peucedanum oreoselinum	**1, II**	2	2,3	3
112. Pinguicula alpina	**3, II**	2	2,1	
113. Platanthera chlorantha	**III**			2
114. Pleurospermum austriacum	**3, II**	2	1,1	1
115. Poa alpina	**3, II**	2	1,1	3
116. Polygonum oxyspermum	**3, II**	1	4	
117. Polystichum braunii	**3, I**	1	1	
118. Polystichum lonchitis	**1, I**	2	4,2	
119. Pulmonaria angustifolia	**1, I**	2	9,6	
120. Pulsatilla patens	**4, III, B, N**	5	2,2,2,3,2	8
121. Pulsatilla pratensis	**III**			15
122. Radiola linoides	**2, I**	1	8	
123. Ranunculus lanuginosus	**3, II**	2	2,2	1
124. Ranunculus nemorosus	**3, II**	1	2	
125. Rhinanthus osiliensis	**3, II, N**	2	5,5	10

Species	Threat and protection status	No. of plot monitoring sites	No. of cases of plot monitoring per plot	No. of status monitoring sites
126. Rhynchospora fusca	**3, II**			3
127. Rubus arcticus	**1, II**	3	2,2,2	
128. Sagina maritima	**3, II**	1	4	
129. Saussurea esthonica	**4, II, N**	3	2,2,2	4
130. Saxifraga adscendens	**2, II**	2	2,2	1
131. Saxifraga hirculus	**2, II, B, N**	3	1,2,2	5
132. Scabiosa columbaria	**3, II**	3	2,1	1
133. Schoenus nigricans	**3, II**			1
134. Selaginella selaginoides	**3, II**	3	2,2,2	3
135. Serratula tinctoria	**4, II**	3	2,1,1	1
136. Silene chlorantha	**2, II**	3	2,2,1	1
137. Sisymbrium supinum	**4, III, B, N**	1	2	4
138. Sorbus rupicola	**2, II**			1
139. Suaeda maritima	**4, II**	2	3,3	4
140. Swertia perennis	**2, I**	3	3,3,3	2
141. Taxus baccata	**4, II**			5
142. Thesium bracteatum	**2, III, B, N**	1	2	
143. Thlaspi caerulescens	**1, II**	2	2,	
144. Trifolium alpestre	**3, II**			1
145. Trifolium campestre	**3, II**			3
146. Trisetum sibiricum	**1, II**	1	2	
147. Veronica dillenii	**5**			1
148. Vicia cassubica	**4, II**			2
149. Vicia lathyroides	**3, II**	1	5	
150. Vicia tenuifolia	**3, II**	2	1,1	1
151. Vincetoxicum hirundinaria	**3, II**	2	1,2	1
152. Viola elatior	**3, II**	3	2,2,1	2
153. Viola selkirkii	**1, II**	1	2	

Appendix 2. Estonian status monitoring form

SEISUNDISEIRE SJ/status monitoring site

Esmaseire/first monitoring Kordusseire/subsequent monitoring

Maakond / County:					
Vald, küla / Community, village: **Metskond, kv. / Compartment, sub-compartment:**					
Geogr. Koordinaadid / Geographical coordinates:		**Lat:**		Long:	
UTM:				Alt: m	
Orientiirid / Landmarks:					
Biotoobi kirjeldus / Biotope description:					
Veereziim / Water regime:					
Valgus / Light conditions:					
Muld / Soil:					
Ümbritsev asustus / Surrounding settlement:					
SL isendite arv / Number of specimens:					
SL populatsiooni suurus pindalaliselt / Extent of population:					
SL arenguaste / Life cycle stage: (%)	**Vegetatiivsed / Vegetative**		**Generatiivsed / Generative**		
Ohtrus / Abundance:	1	2	3	4	5
Vitaalsus / Viability:	1	2	3		
Inimmõju / Human impact: liik / class					
Inimmõju / Human impact: aste / degree	1	2	3		
Kahjustused: liik / Herbivory damage	-				
Kahjustused: aste / Degree of damage	1	2	3		
Muutused liigi seisundis / Changes in state: (kordusseire korral / for subsequent monitoring)					

Kuupäev / Date: ____________________
Seiraja nimi / Name: ____________________
Aadress / Address: ____________________
tel. / tel. ____________________

Monitoring of vascular plants in Finland

5

Terhi Ryttäri, Eija Kemppainen & Katariina Mäkelä

5.1 Introduction

Finland's Nature Conservation Act obliges the national authorities to organise the monitoring of all native species so that the results would enable assessments of the favourable conservation status of species – as defined in the European Union's Habitats Directive – and the detection of any changes in this status. This species monitoring obligation concerns Finland's entire flora and fauna, although special attention should be paid to threatened species. On a nationwide level this monitoring is supervised by the Ministry of the Environment, although other institutes actually carry out the monitoring work, particularly the Finnish Environment Institute, Finland's 13 Regional Environment Centres, Metsähallitus – Forest and Park Service, and the Finnish Forest Research Institute (METLA). (Metsähallitus and METLA administer Finland's state-owned nature reserves and national parks.) The Finnish Museum of Natural History and other museums also have an important role in monitoring, and in the collection and management of data on Finland's flora and fauna, while the contributions of amateur naturalists and voluntary workers are additionally invaluable. This presentation will concentrate on issues related to the monitoring of vascular plants.

Data has been fairly systematically collected on the occurrences and populations of threatened species since the beginning of the 1980s, when the work to compile the first Red Data Book of Finland was initiated (Rassi et al. 1986). The Red Data Book has since been updated twice (Rassi et al. 1991, Rassi et al. 2001) with the collection of information for the database on threatened species becoming steadily more efficient, especially in the 1990s. The number of threatened species in Finland is 1,505 of which 180 are vascular plants (Rassi et al. 2001). By 22nd October 2003, information on 163 threatened vascular plant taxa (categories CR, EN, VU), 15,087 sites (including also disappeared sites) and 25,083 observations had been entered into the threatened species database run by Finland's environmental administration. These figures change daily as the entering of the data proceeds. In spring 2002, a major renovation of the threatened species database system was completed, and this database now forms part of the environmental data system "Hertta" maintained by Finnish Environment Institute.

The amount of information on threatened species has increased enormously in Finland during the last decade. Detailed guide books have been so far published about threatened polypores (Kotiranta & Niemelä 1996), butterflies (Somerma 1997) and vascular plants (Ryttäri & Kettunen 1997, Rautiainen et al. 2002), while an ecological flora of mosses was published in 2002 (Ulvinen et al.). Several conservation programmes for threatened species have also been published, mostly concerning vascular plants (e.g. Pykälä & Vuorinen 1996, Hakalisto et al. 2000, Rintanen & Kare 2000) and butterflies (Wahlberg 1998, Kuussaari et al. 1998, Pajari 2002), although one programme covers a group of lichens (Halonen et al. 1997).

Although the dataset available is rather extensive, the use of this data for monitoring purposes has so far been quite ineffective. This is partly because much of the data is inadequate, and partly because of the nature of the whole monitoring regime, where little attention has been paid to data analysis and to responsibility for analysis. It is clear, however, that in Finland today good tools are already available for monitoring – including good background information on several groups of species, skilled personnel and able amateurs, and a workable data system. As the new data system is more user-friendly and versatile, it is hoped that data collection will increase, and that the new facilities will encourage more active data analysis. It is important that data analysis and reporting are improved, so that the necessary conservation and management activities are carried out in time. Another extremely important challenge is to maintain and increase the motivation of volunteer amateurs, and to educate and encourage future generations of both professional and amateur biologists.

5.2 Finland's national biodiversity monitoring programme

In 1996, the Ministry of the Environment set up a National Commission for Biological Diversity, which in 1997 drafted The National Action Plan for Biodiversity in Finland 1997–2005 (The Finnish Environment 137). This National Action Plan set out 124 specific measures to be taken by 2005 to ensure the conservation and sustainable use of biodiversity. One of these measures deals with monitoring biodiversity and information management. In 1999, a research, monitoring and data systems expert group was set up, and the group's proposals for a national monitoring system for biological diversity were published in 2001 (The Finnish Environment 532; English summary in Kangas & Jäppinen 2002). The expert group divided the monitoring of biological diversity into two levels: *general monitoring*, to observe the overall changes in the environment, flora and fauna; and *special monitoring*, related to various national and international statutes and agreements which oblige Finland to monitor threatened and internationally significant habitats, species and populations. Special monitoring most often requires case-specific designations, and the expert group concentrated in its first report primarily on general monitoring. The group's proposals for arranging special monitoring, as required for the assessment of threatened species, are still being drawn up for publication at a later date.

Very many species fall within the scope of special monitoring, with the number of threatened species alone exceeding 1,505 in Finland (Rassi et al. 2001). The number of species to be accounted for in the planning the special monitoring regimes amounts to 2,805 in all. It is not feasible for all of these species to be monitored with equal accuracy. Prioritisation is needed to rank the monitored taxa according to the urgency of monitoring.

The taxa to be monitored will be divided into priority groups based on certain biological and administrative criteria, defined both nationally and internationally. The most important national criteria for prioritisation are the respective status of the species in the Nature Conservation Decree (1997) and the latest Red Data Book 2000 (Rassi et al. 2001). The key international criteria for prioritisation are the EU Habitats Directive, other international agreements (e.g. the Bern Convention 29/1986) and status as species for which Finland has international responsibility (as listed in Rassi et al. 2001).

Monitoring of species belonging to the *highest priority group* should be arranged most urgently, and will be most intensive. The species in the *lowest prior-*

ity group need no monitoring, unless some factor outside the defined prioritisation criteria makes this necessary. Such factors could be the economic utilisation of the species, its value as an environmental indicator, or its place in a typical species assemblage of a monitored habitat type.

5.3 Monitoring threatened vascular plants in Finland

The total number of vascular plant taxa in Finland is approximately 3,200 (excluding established and casual aliens). The number of threatened (CR, EN, VU) vascular plants in Finland is 180, while 93 plants are classed as near threatened (NT) (Rassi et al. 2001). Altogether 301 vascular plant taxa are either threatened, near threatened, listed in the Habitats Directive, or listed as being Finland's international responsibility. So far, there has not been any systematic plan concerning how all these plants should be monitored. Several species and sites have been monitored at best yearly, but numerous species and sites have been monitored only at irregular intervals, and with varying methods, while others have been completely outside any monitoring regimes. A general plan to improve this situation is urgently needed.

The first step towards improving the disjointed monitoring of vascular plants was to publish a monitoring guide (Syrjänen & Ryttäri 1998), which concentrated on improving and standardising the methodology in use. Since 1997, regional monitoring meetings have been held in different parts of Finland, allowing all the parties involved in monitoring to discuss how the monitoring of threatened vascular plants should be organised in their area. These discussions have been very useful in planning the priorities for monitoring, and have also facilitated the compilation of national and regional needs and opinions.

In connection with the work of the Research, monitoring and data systems expert group (see Chapter 5.2) a review was made in the beginning of 2003 of the monitoring situation for different plant groups. The taxa concerned were divided into four groups according to the present monitoring situation and the practical possibilities to monitor the species. The situation for vascular plants has advanced furthest, with 23 taxa in group A, meaning that monitoring is already quite well established; while 67 taxa in group B are at a stage where monitoring can be started fairly easily, as soon as suitable personnel and finances can be arranged. A further 211 (70 %) of the vascular plant taxa to be monitored belong to groups C (monitoring possible after methods are improved and/or experts are trained, for instance) and D (monitoring not possible because of a lack of knowledge of biology or sites), meaning that a lot of work is needed before their monitoring can be properly initiated.

The next step needed in arranging the monitoring of vascular plants is a national monitoring programme, which should be drawn up according to factors such as the findings of the regional meetings described above.

5.4 Monitoring in Finland of vascular plants listed in the Habitats Directive

The Finnish Environment Institute has been setting up monitoring as required by the Habitats Directive since 1998. Where monitoring of habitat types is concerned, this work has been started from scratch, since such monitoring had not been carried out in Finland before. Species monitoring is somewhat better established, with data already available for several species, although monitoring has not always been systematic.

A total of 114 species and 69 habitat types mentioned in the Habitats Directive Annexes I, II or IV are found in Finland. Thirty of these taxa are vascular plants (Table 1). Of these, 21 are classified as threatened (CR, EN, VU), seven as near threatened (NT) and two as least concern (LC) (Rassi et al. 2001). Finland additionally has international responsibility for 15 vascular plants listed in the Habitats Directive (Rassi et al. 2001). These are species whose populations in Finland make up at least 15% of the whole European population. All the vascular plants listed in the Habitats Directive are protected under the Nature Conservation Decree (1997).

Table 1. Vascular plant taxa listed in the Habitats Directive Annex II occurring in Finland, with their threat categories in Finland (Rassi et al. 2001) and monitoring priority groups (Kemppainen & Mäkelä 2002).

Taxon	Threat category	Priority group (explanations: see below)
Agrimonia pilosa Ledeb.	EN	I
Alisma wahlenbergii (Holmb.) Juz.	VU	I
Pulsatilla patens (L.) Mill.	EN	II
Arctagrostis latifolia (R. Br.) Griseb.	VU	II
Arctophila fulva (Trin.) Andersson var. *pendulina* (Laest.) Holmb.	CR	I
Arenaria pseudofrigida (Ostenf. & O.C. Dahl) Juz. ex Schischk. & Knorring	NT	III
Artemisia campestris L. ssp. *bottnica* Lundstr. ex Kindb.	CR	I
Botrychium simplex E. Hitchc.	EN	I
Calypso bulbosa (L.) Oakes	VU	II
Carex holostoma Drejer	NT	III
Cinna latifolia (Trevir.) Griseb.	NT	III
Crepis tectorum L.; incl. *C. czerepanovii* Tzvelev ssp. *nigrescens* (Pohle) Á. Löve & D. Löve	CR	I
Cypripedium calceolus L.	VU	II
Diplazium sibiricum (Turcz. ex Kunze) Kurata	LC	III
Draba cinerea Adams	NT	III
Dryopteris fragrans (L.) Schott	NT	III
Hippuris tetraphylla L. f.	EN	II
Liparis loeselii (L.) Rich.	EN	
Moehringia lateriflora (L.) Fenzl	VU	II
Najas flexilis (Willd.) Rostk. & W. L. E. Schmidt	EN	I
Najas tenuissima (A. Braun) Magnus	EN	I
Persicaria foliosa (H. Lindb.) Kitag.	NT	III
Primula nutans Georgi var. *jokelae* L. Mäkinen & Y. Mäkinen	EN	II
Puccinellia phryganodes (Trin.) Scribn. & Merr.	EN	I
Ranunculus lapponicus L.	LC	III
Saxifraga hirculus L.	VU	II
Silene furcata Raf. ssp. *angustiflora* (Rupr.) Walters	CR	I
Sorbus teodori Liljef.	CR	
Trisetum subalpestre (Hartm.) Neuman	NT	III
Viola rupestris F. W. Schmidt ssp. *relicta* Jalas	VU	II

Finland's environmental administration has extensive information on vascular plants, which is the species group where the planning of monitoring regimes has proceeded furthest – indeed a general plan for the monitoring of vascular plants listed in the Habitats Directive was published in spring 2002 (Kemppainen & Mäkelä 2002).

Inventories and population mappings of many of the listed plants have already been carried out to some extent, but these surveys have seldom covered whole distributions or been temporally continuous. In order to establish a basis for the general plan, the present status of all 30 vascular plants was evaluated. Surveys revealed the numbers and locations of present occurrences, also examining former occurrences and possible occurrences. The need for additional information was also assessed.

The 30 vascular plant taxa listed in the Habitats Directive are known to occur in a total of roughly 2,700 sites in Finland (as observed since 1980), while more than 800 further sites are currently awaiting resurveying. The distribution and abundance of these species vary greatly. The four most abundant plants, *Calypso bulbosa, Cypripedium calceolus, Saxifraga hirculus* and *Ranunculus lapponicus,* occur in altogether more than 1,500 sites; whereas the 13 rarest plants only occur in a total of approximately 75 sites.

5.4.1 Prioritising the monitoring of vascular plants listed in the Habitats Directive

To facilitate the implementation of monitoring, the 30 listed vascular plants were assessed according to a prioritisation process in order to divide the taxa into three priority groups (I-III), to be monitored with differing intensity, methods and frequency. Ten taxa were placed into priority group I, with nine species in each of the priority groups II and III. *Liparis loeselii* and *Sorbus teodori*, which both occur only in the Åland Islands, were left outside this process.

Priority group I

All ten taxa in the first priority group have been classified as threatened (Rassi et. al 2001). *Alisma wahlenbergii* is also a priority species. These taxa either occur in only a few localities in Finland, or have a distribution restricted within a small geographical area. The ten taxa occur in a total of around 130 localities, of which 70 (54%) are within Natura 2000 sites. The populations of these ten taxa belonging to the first priority group will be monitored most intensively, with the monitoring regime generally covering all their populations.

Priority group II

The second priority group includes nine species which all have a high national and international conservation value. Many of these taxa may still occur in numerous localities, but areas of suitable habitat may have declined or deteriorated due to human impacts, and many sites may be in need of management or restoration. The taxa in this priority group currently occur at a total of approximately 1,800 sites, 630 (35%) of which are within Natura 2000 sites. As the number of sites concerned is so high, only a representative sample of the occurrences each taxon will be selected for monitoring. In cases where a species occurs in fewer than 30 sites, all occurrences will be monitored.

Priority group III

The third priority group consists of nine nationally or internationally important vascular plant taxa. The taxa *Arenaria norvegica*, *Carex holostoma*, *Draba cinerea*, *Dryopteris fragrans* and *Trisetum subalpestre* each occur within very restricted ranges in northern or north-eastern Finland, whereas *Cinna latifolia*, *Diplazium sibiricum* and *Persicaria foliosa* are distributed more widely throughout the country. *Ranunculus lapponicus* is fairly common in northern Finland. The exact distributions of some of these taxa still need clarifying, but in most cases the sites concerned are not in need of urgent management measures.

The taxa in the third priority group occur in a total of approximately 800 sites, of which about 330 (40%) are within Natura 2000 sites. *Diplazium sibiricum* and *Ranunculus lapponicus* have viable populations in Finland, and are classified as Least Concern (LC; Rassi & al. 2001), while all the other taxa are classified as Near Threatened (NT). The habitats of these taxa are generally in fairly good natural condition, and the threats to the taxa are clearly less acute than those facing taxa in the first and second priority groups. A representative sample of these sites will be chosen for the monitoring regime, and in cases where a species occurs in fewer than 30 sites, all occurrences will be monitored.

5.5 Conclusions

The monitoring of threatened vascular plants and other species listed in the Habitats Directive is only one part of the wide field of biodiversity monitoring. In Finland, the implementation of the monitoring required by the Habitats Directive has been planned so that the same data collection can also meet national needs. Where habitat types are concerned, the interface between international and national needs is clear, as the habitats listed in the Habitats Directive coincide well with the biologically important and rare habitat types in Finland. In contrast, the list of species mentioned in the Habitats Directive is distinctly shorter than Finland's own list of nationally threatened species. This means that the monitoring of species listed in the Habitats Directive only partly meets the national need for the monitoring of Finnish flora and fauna.

In future, calls for increased monitoring of biodiversity are likely to grow still further, both nationally and internationally, so it is extremely important to plan such monitoring carefully. Finland's general plan for monitoring the vascular plants listed in the Habitats Directive (Kemppainen & Mäkelä 2002) can be seen as the first step in the establishment of a monitoring regime focusing on species and habitat types listed in the Habitats Directive. The next step is to design species-specific monitoring plans, where the sites to be monitored are named, detailed instructions are given on monitoring methods, timetables are clearly defined, and the need for resources is carefully estimated.

5.6 References

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Appendix. I Data collection sheet for the monitoring of vascular plants in Finland

Finnish Environment Institute
Nature Unit
P.O.B. 140, 00251 Helsinki

FIELD OBSERVATION SHEET

VASCULAR PLANTS

First survey X Monitoring survey Threat category: EN

Date: 12.8.2002

SPECIES: Agrimonia pilosa

Name of surveyor: Mika Kalliovirta

Address and phone no.:

Site name: Vanhakartano

GEOGRAPHICAL LOCATION

Municipality: Asikkala Province:

Register village: Vähä-Äiniö Biogeographical province: Tavastia australis

Topographical map: 213412

Site co-ordinates (Grid 27°): 6796 3416

Real estate registration number:

Landowner(s): Mrs. Pupponen

Contact with the landowner: X yes no

Protected area (name): Natura 2000: FI030/017

PLANT WAS NOT FOUND PLANT WAS NOT SEARCHED FOR

Site was destroyed: Reason:
Site had changed: ☐ How?

Other reason, what?

COPY SENT TO: Regional environment centre Metsähallitus
Other

SITE DESCRIPTION

EXACT GEOGRAPHICAL LOCATION (map, drawing): NW-side of the old cowhouse

EXTENT OF SUITABLE HABITAT: Appr. 200 square metres

HABITAT DESCRIPTION (vegetation, soil, moisture, nutrients, topography, exposure etc.): W-slope, rich soil, stony. A former meadow between a rock and a growth of Matteuccia

Habitat type (code): 14

Associated species, dominant, or characteristic species: Dactylis glomerata, Dryopteris filix-mas, Hypericum maculatum, Rubus idaeus, Pimpinella, Knautia arvensis, Vicia sepium, Trifolium medium

Rare and threatened species: Dianthus deltoides, Agrimonia eupatoria, Verbascum nigrum

Competing species: grasses, Rubus idaeus, Prunus padus

THREAT FACTORS: Shade by trees, overgrowth of field-layer

RECOMMENDATIONS FOR CONSERVATION AND MANAGEMENT: certain trees should be removed, mowing. See the management plan!

CONSERVATION AND MANAGEMENT ACTIVITIES CARRIED OUT: The site has been mowed several times in 1980s and 1990s. Last time 1997?

HISTORY OF THE SITE Seppänen & Rantanen (1985), Kemppainen & al. (1987), Kettunen et al. (1988), Rajala & al. (1992), Kemppainen & al. (1993), Järvinen (1994), Järvinen (1997), Kemppainen (2000) – all field observations. Management reports by Anttila (-95-96)

OBSERVATIONS

EXTENT OF THE SITE

Subpopul. A: 3,5 × 3 m ≈ 10,5 m²

Subpopul. B: 0,4 × 0,2 m ≈ 0,1 m²

NUMBER OF INDIVIDUALS, SHOOTS OR TUSSOCKS (vegetative, flowering, juvenile)

A: 48 gener. + 47 veget. shoots + 38 "juvenile shoots"

B: 12 veget. shoots

AGE OR SIZE OF INDIVIDUALS, AND THEIR CONDITION

A: vital, high shoots (flowering x̄ 100 cm)

B: fragile and weak (height 10-40 cm)

PHASE OF FLOWERING (number of buds, flowers, fruits)

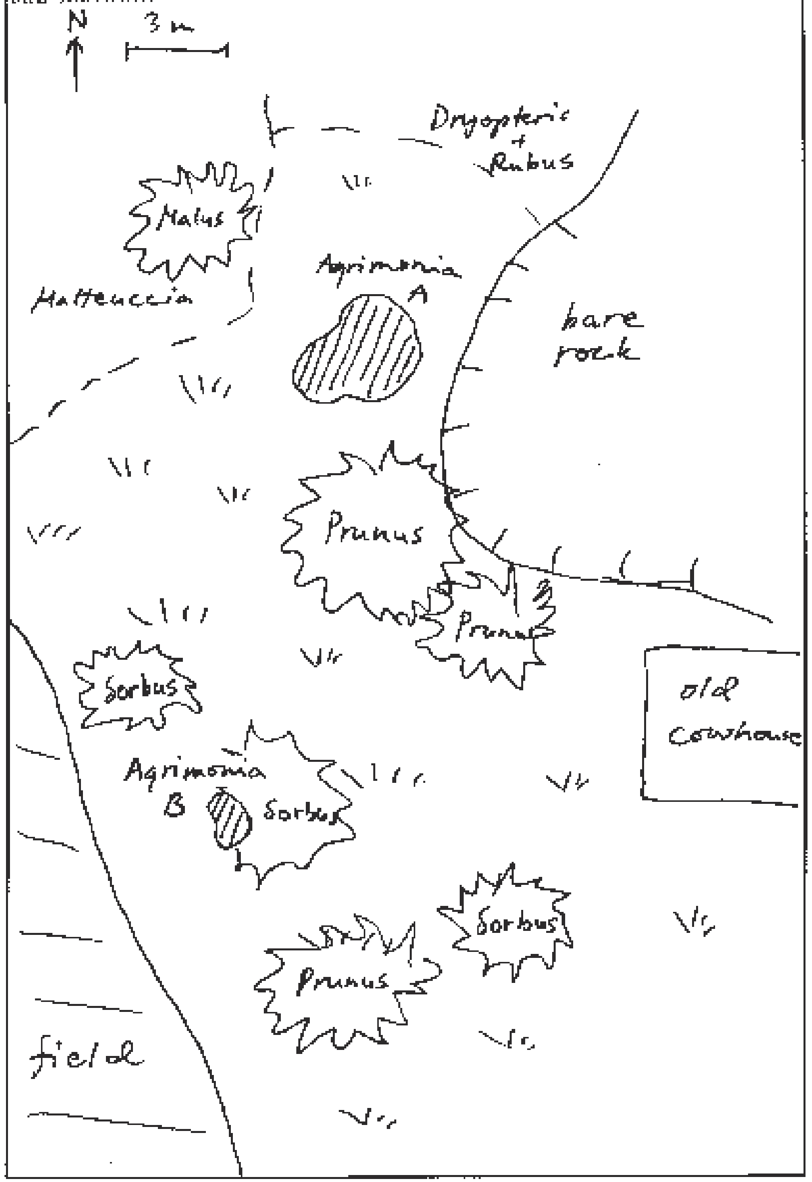
Fruits are ripening, some flowers

ESTIMATED SEED SET Moderate

PREVIOUS YEAR INDIVIDUALS –

OTHER INFORMATION (herbarium specimens, photographs etc.)

MAP/DRAWING



6 Case studies

6.1 Introduction

The purpose of this project was to assess various monitoring methods in the monitoring of ecologically and biologically different vascular plant species, in order to determine which types of measurements are most suitable for monitoring purposes, and to assess where species-specific applications may be needed.

The original idea in choosing the target species was to find species of common interest. We hoped to select plant species which would be either threatened in both Estonia and Finland, or threatened in one country and more common in the other, so that the monitoring might also produce useful information for conservation purposes. However, it proved surprisingly difficult to find such species, and the original selection had to be changed considerably. The first species selected were a group of orchids, including *Cypripedium calceolus*, *Epipactis palustris*, *E. atrorubens, Calypso bulbosa, Epipogium aphyllum* and *Coeloglossum viride.* But *Calypso, Coeloglossum* and *Epipogium* were later omitted since there was too little existing data on these species.

We eventually decided to use data on three species from the original selection (*Cypripedium, Epipactis palustris* and *E. atrorubens*) with additional material on other species to ensure that the aims of the report could be adequately fulfilled. – *Pulsatilla patens* and *Agrimonia pilosa* are both long-lived perennial species of European Community interest. They occupy quite different habitats – the former being associated with dry forests, and the latter with grasslands. The addition of *Rhinanthus osiliensis* enabled us also to assess the problems associated with annual species. *Ligularia sibirica* is a perennial wetland species for which there was a longer series of monitoring data available. Finally, *Neotenia ustulata*, was added to help us examine how short-lived plants exhibiting regular dormancy should be monitored.

Considering the great diversity of habitats, plants, plant morphology, life-cycle strategies and other issues affecting monitoring regimes, our selection of case-studies inevitably remains limited. We nevertheless believe that many important factors and problems can be usefully examined through the following case studies.

6.2 *Pulsatilla patens (L.) Mill.*

English: Eastern pasque flower
Estonian: Palu-karukell
Finnish: (Hämeen)kylmänkukka

Mika Kalliovirta, *Ülle Kukk* & *Terhi Ryttäri*

6.2.1 Introduction

Pulsatilla patens has declined in recent decades in many European countries, and is included in several national Red Lists. In Estonia the species is protected in Category III (see page 14; Kukk 1999) and classified as care-demanding (Lilleleht 1998). In Finland *P. patens* is endangered (EN; Rassi et al. 2001). *P. patens* is also a species of European Community interest and is thus listed in the Habitats Directive.

Changes in land use, and especially in forestry practices, are the main causes of the decline of *P. patens*. A drastic decline in cattle grazing in forests and increasingly efficient fire prevention have both led to considerable changes in the understorey vegetation of the species' growth sites. Dense moss layers and high, grass-dominated vegetation can completely inhibit regeneration.

For this report two different data sets were used for the monitoring of *P. patens.* The Estonian case deals with monitoring data obtained through repeated visits to the same sites, whereas in Finland attempts were made to analyse the viability of a population based on a single one-off population survey (Kalliovirta 2000).

6.2.2 Biology and ecology

Pulsatilla patens (Ranunculaceae) is a monoecious, long-lived perennial hemicryptophyte. The rhizome is vertical, and due to the branching of the rhizome, older plants may form clearly definable tussocks. Vegetative spreading has been observed to occur by infrequent splitting of the larger tussocks (Rysina 1981, Wildeman & Steeves 1982). However, actual reproduction takes place only by seeds.

P. patens flowers in early spring – from mid April to the beginning of May in Estonia, and between late April and mid May in Finland. Protogynousity favours cross-pollination, but later the flowers are also capable of self-pollination (Jonsson et al. 1991). The reproductive success rates of *P. patens* in Finland seem to be fairly high. On average, 62% of flowers produced viable achenes, with an average of 103 viable achenes per flower (single year observation, Kalliovirta 2000). Seeds are dispersed from mid June. Despite having traits of anemochory, dispersal distances seem to remain short. The germination rate is highest directly after dispersal (Kalliovirta 2000), and germination occurs immediately once there is enough moisture available. In unfavourable conditions, germination can be delayed until the following spring. Only a transient seed bank is formed (Thompson et al. 1991).

In Estonia, the majority of *P. patens* populations are found in boreal heath forests of *Cladina* or *Calluna* type sites dominated by Scots pine (*Pinus sylvestris*), and in dry boreal forests of *Vaccinium vitis-idaea* type sites, but they also occasionally occur in more humid *Vaccinium myrtillus* type growth sites. In alvar areas, *P. patens* is more frequently found in sparse forests of *Arctostaphylos*-, and

Calamagrostis-alvar site types. The biggest and densest populations in Estonia were found in sparse alvar forests and on open sandy slopes, where light conditions are good and coverage of the field and the ground layer is low (Pilt & Kukk 2002). In Finland, *P. patens* grows mainly on eskers and adjacent sandy areas (Uotila 1996). Habitats are typically open, fairly dry pine forests and mixed forests, often on the warmer slopes of eskers.

Pulsatilla patens is favoured by moderate disturbance, and is sensitive to overgrowth. Thus, certain activities such as thinning and sand exctraction may to some extent benefit populations. Almost all recent localities of *P. patens* in Finland were grazed some decades ago (Uotila 1996). *P. patens* also grows apophytically on roadsides, along tracks and in other open anthropogenic habitats which have been mown or burned (Kukk & Pilt 2002).

6.2.3 Distribution and population sizes

Pulsatilla patens sensu lato has a widespread circumpolar distribution, but the European subspecies *patens* is concentrated in north-eastern parts of Europe. In Germany and Sweden it has a very fragmented distribution, while from Poland to the Baltic Countries and western parts of Russia its distribution is typically sparse but continuous.

In Estonia, *P. patens* has two main distributions – in eastern and south-eastern Estonia, and in northern and north-western Estonia. The species is completely absent from Estonia's islands, and only has a very scattered distribution in western and north-eastern Estonia. *P. patens* has disappeared from the surroundings of larger cities (Tallinn, Tartu), and vanished from central Estonia back in the beginning of 20th century. In Finland, *P. patens* occurs only in the Province of Southern-Häme, where it is fairly rare.

Populations of *P. patens* in Estonia vary considerably in size. Twenty-nine populations can be distinguished when using a definition that populations are separate when the distance between them is at least 1 km. Five populations consist of about 10,000 plants, five of about 1,000 plants, 13 consist of about 100 plants, and the six smallest populations have only about 10 plants. The total number of plants is approximately 56,000–57,000 (Pilt & Kukk 2002).

The Finnish population of *P. patens* consists at the moment of approximately 160 sub-populations, which can be pooled into some 40 clusters containing a total of about 3,000 adult individuals. Most of these populations are very small – 105 populations have fewer than 10 individuals, while 38 populations have 10-29 individuals, 15 populations consist of 30-100 individuals, and only five populations have more than 100 individuals (Ilmonen et al. 2001).

6.2.4 Monitoring in Estonia

Methods

In Estonia five plot-monitoring sites of 10 x 10 m were established in 1994 (for methods, see page xx). Sites were chosen in the following habitats: one in a heath forest (Nursi), three sites in dry boreal forests (Hargla, Külaaseme and Vastseliina) and one in an alvar forest (Jalase). Over the period 1994–2000 the sites were monitored twice with an interval of 5 years. The Nursi and Vastseliina sites were additionally monitored twice a year, in May and June. In 1999 and 2000, all previously-known populations were checked using status monitoring methods to assess their size and condition, and describe the habitat type (Pilt & Kukk 2002).

The total size of each population was only estimated roughly, to the nearest hundred, since the plants were typically distributed quite sparsely over wide areas.

The aim here was to assess:

- population sizes, and how they have changed over time
- any trends in density and in viability
- any changes in habitats
- the possible factors behind any such changes.

Results

The total number of plants registered at monitoring sites amounted to around 21,000, with the biggest populations at Nursi and Jalase. The number of plants recorded at each plot are presented in Table 1. These figures have decreased over the five-year period for the Vastseliina and Külaaseme sites, and increased at Hargla and Jalase. Numbers at the Nursi site remained fairly stable. As very few plants were observed at the Külaaseme site, this data has not been further processed.

The importance of timing in the monitoring of *Pulsatilla* can be seen in the two populations monitored twice during the same growing season (Fig. 1). At Vastseliina, 19 tussocks were observed on 5th May 1999, while 164 tussocks were counted on 8th June. At Nursi, the number of tussocks had increased from 58 in May to 99 in June. At Jalase, the second monitoring after the five-year gap was made two weeks later in the year, and consequently the number of vegetative plants observed was much higher (611 compared to 184 – although other factors during the intervening period of 5 years could also have had some impact here).

Table 1. Monitored populations of *Pulsatilla patens* in Estonia 1994–2000.

Site	Total no. of plants	No. of plants in plot	No. of generative plants	Mean height of flowering shoots, cm	Habitat	Monitoring date
Vastseliina		31	31	14	Dry boreal forest of Polytrichum-Vaccinium vitis-idea type	09.05.1994
Vastseliina	~100	19	10	18		05.05.1999
Vastseliina		164	10	26		08.06.1999
Vastseliina		153	29	34		20.06.2000
Külaaseme	Scattered over a large area	8	8	35	Dry boreal forest of Vaccinium vitis-idea type	17.05.1994
Külaaseme		1	1	22		15.05.1999
Hargla	~100	53	0		Dry boreal forest of Polytrichum-Vaccinium vitis-idea type	26.07.1995
Hargla		79	1			08.07.2000
Nursi		57	44	25	Calluna heath forest	10.05.1994
Nursi	~150	58	22	24		07.05.1999
Nursi		99	22	27		19.06.1999
Nursi		109	16	22		20.06.2000
Jalase	Hundreds	184	147	16	Alvar forest of Arctostaphylos type	04.05.1994
Jalase		611	112	23		20.05.1999

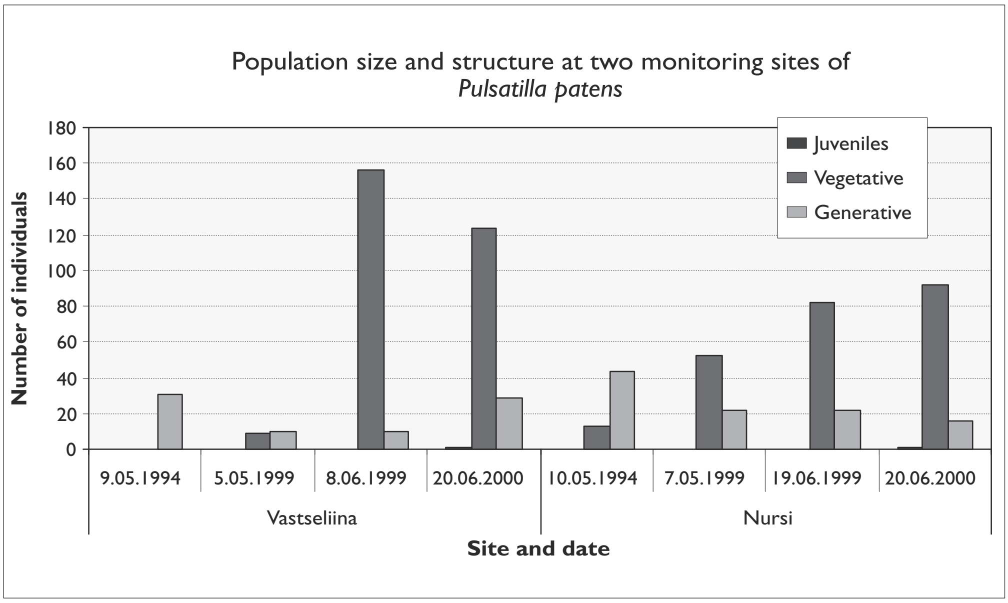


Figure 1. Population size and structure of Pulsatilla patens *at two monitoring sites surveyed twice during the same season.*

Most of the populations observed were more or less scattered, while they were noted to be typically denser at roadsides and the edges of forest, and sparser inside the forest. The density of the populations is illustrated in Fig. 2, where the columns indicate the mean numbers of plants per square metre. This type of monitoring data was applied where monitoring was done in the early summer (except for one session at Jalase). Declining trends were evident in dry coniferous forest habitats, whereas the trends were upwards in alvar habitats. Densities were higher in alvar habitats than in boreal forests at both monitoring stages. The numbers of shoots were considerably higher even when alvar plots were monitored in early May, when vegetative shoots were not yet fully developed (Fig. 2). The rapid increase in density observed during the second monitoring session could be explained by the monitoring date being two weeks later.

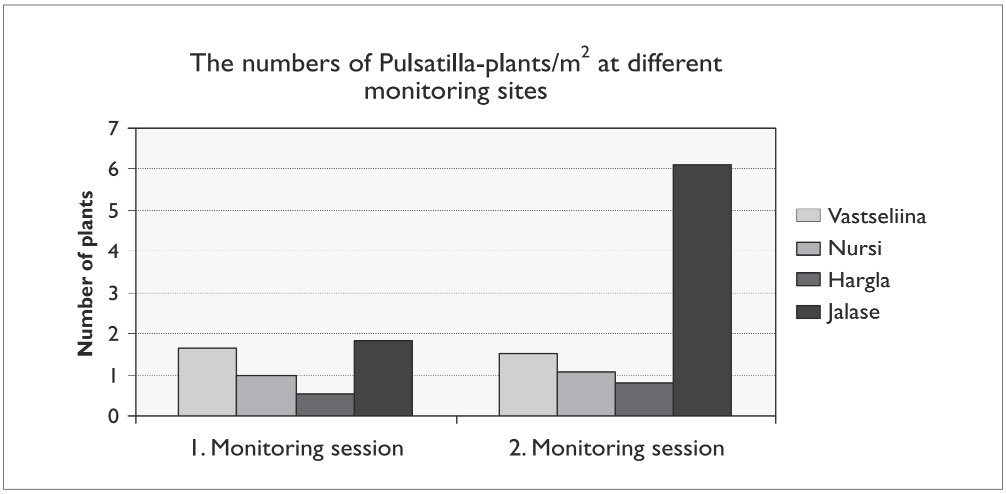


Figure 2. The numbers of Pulsatilla patens *plants per square metre at different monitoring sites.*

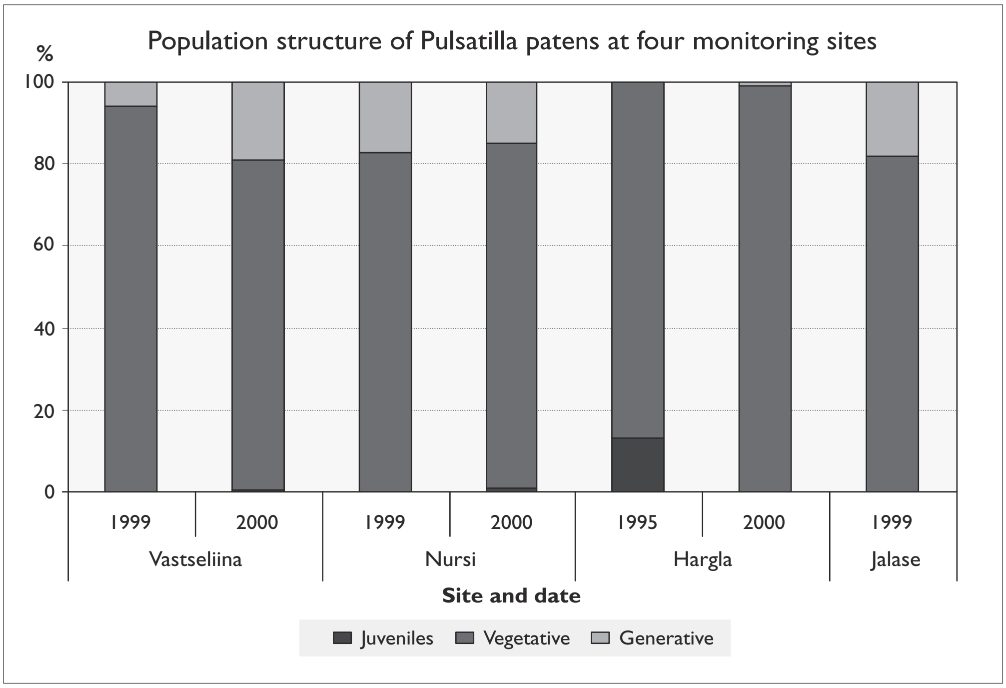


Figure 3. Population structure of Pulsatilla patens *at four monitoring sites.*

The study of the population structure has used data from years when monitoring was done later and all stages were fully developed. As mentioned above, early May is good for finding flowering plants, but seedlings and vegetative shoots are not developed yet. In general, the observed ratio between vegetative and generative plants was roughly 4:1 (Fig. 3). The absence of generative plants at the Hargla site may reflect the real situation, but could also be explained by the monitoring date being so late that flowering shoots had possibly withered already.

The heights of flowering plants correlate negatively with light intensity: in boreal forests the highest plants were 35 cm, in heath forests 22 cm and in alvar forests 23 cm. While the shoots of *Pulsatilla* continue growing in height throughout flowering until fruiting occurs, this parameter cannot be relied on to estimate population viability. It can, however, be useful in comparisons between plants in different habitat types.

Conclusions

1. Monitoring methods. Timing is very important. The difference between the results obtained during these two monitoring sessions can be largely explained by the differing monitoring dates. The 1994–1995 sessions were earlier, and flowering plants were largely visible. Just two weeks later the situation had noticeably changed, with vegetative plants more prominent. The best time for monitoring is between flowering and fruiting, when leaves have already developed, but flower shoots have not yet dried up.

2. Monitoring results. The main reason for the variations in density and height is probably the better light conditions in alvars, rather than their different soil characteristics. The explanation for the drastic decrease observed in the Külaaseme plot seems to be the increase in moss layer density. The increase in the number of plants at Hargla can be explained by the thinning carried out during the intervening period, which had improved light conditions. The significant increase at

Jalase can probably be explained by the fact that the monitoring in 1999 was made two weeks later than in 1994, with the ratio of vegetative and generative plants consequently changing from 0.25 in 1994 to 4.45 in 1999.

Very scarce or absent germination of seedlings, and high numbers of vegetative plants compared to generative plants may both indicate that populations are neither viable nor regenerating, especially in heath and dry boreal forests. None of the populations studied seemed to be increasing.

6.2.5 Population analysis of **Pulsatilla patens** *in Finland*

Since the 1930s, populations of *Pulsatilla patens* have been monitored several times by counting individuals. This long-term monitoring has allowed a general estimate to be made of the species' decline (Uotila 1996).

In 1999 a more detailed population study was carried out on *P. patens* populations in Finland (Kalliovirta 2000). The basic idea was to examine whether it is possible to analyse the viability of populations by collecting data within a single growing season, and comparing separate populations to one another. Another aim was to compile environmental data on a variety of populations to find out which environmental factors might most affect the structure and survival of the species' populations.

Methods

The population structure of 48 populations was surveyed. Individuals were classified into the following life-cycle stages: generative adults, vegetative adults and seedlings. The numbers of flowers in each generative plant were also recorded.

A more detailed survey of the population structure was performed for the 24 largest populations, where the sizes of each individual plant were also measured. The size of an individual was determined by measuring the basal area of the tussock, with plants then accordingly classified into six size categories. Measuring the basal area of a plant gives a better idea of the age of the plant than merely counting the number of leaves in a tussock. Using size-distribution as a criterion, populations were then divided into increasing, stable and decreasing population types according to Oostermeijer (1994).

A set of environmental parameters was measured for all 48 study-populations, including:

- *field layer coverage;* measured as a percentage coverage of the vegetation of the total area of the site,
- *ground layer coverage;* classified into four categories: 1) plenty of open mineral soil; 2) some patches of open mineral soil; 3) a thin, closed moss and lichen layer; 4) a thick, closed moss and lichen layer,
- *litter coverage;* classified into five categories: 1 (little litter) – 5 (abundant litter)
- *light conditions;* classified into four categories: 1) open, warm slope; 2) semi-open site; 3) sparse forest; 4) closed forest.

Environmental variables were estimated as averages for entire populations. The relationships between environmental data and population variables were analysed with Spearman rank correlation coefficients. Further analysis to study the impact of the environmental variables on population properties was carried out by modelling the data with Generalised Linear Modelling (GLM) (Crawley 1993). As this kind of analysis is quite complicated to use in routine monitoring regimes, we will not present the method here in detail, although some of the central results are briefly discussed.

Results

Analysis of the population structure

Eight populations out of 24 were evidently increasing. In increasing populations relatively many individuals were in the two smallest size classes, the proportions of seedlings were high (35% on average) and the proportions of generative plants averaged 10%. Vegetative adults accounted for 55% of all individuals (Fig. 4).

Twelve populations out of 24 were classified as being stable. In stable populations there were individuals in all size classes, but the largest plants were dominant (Fig. 5). A stable structure in a plant population reflects a situation where the proportions of the individuals in various life-cycle stages remain almost un-

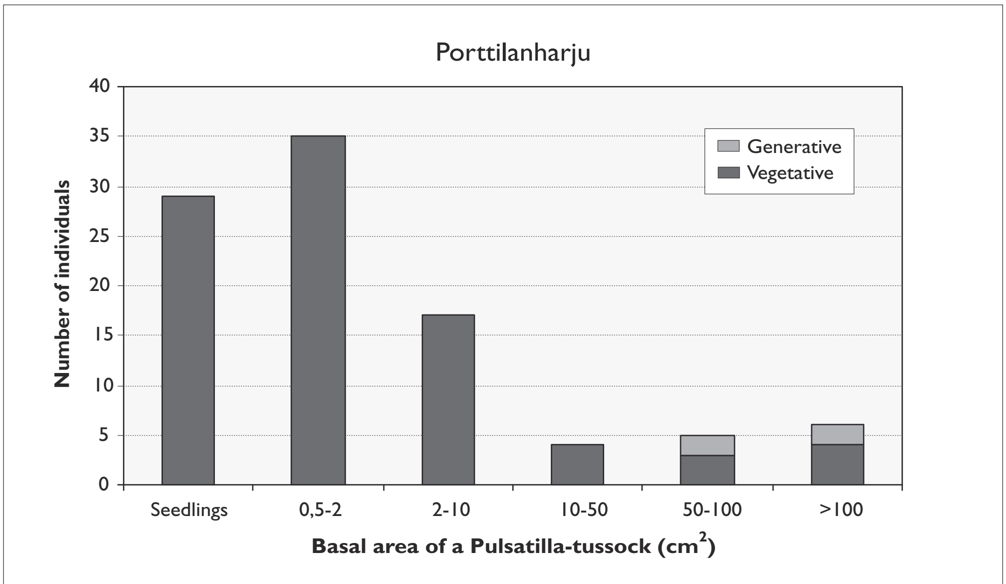


Figure 4. Size distribution of Pulsatilla patens *individuals in an increasing population – an example population at Porttilanharju, Finland. (Kalliovirta 2000)*

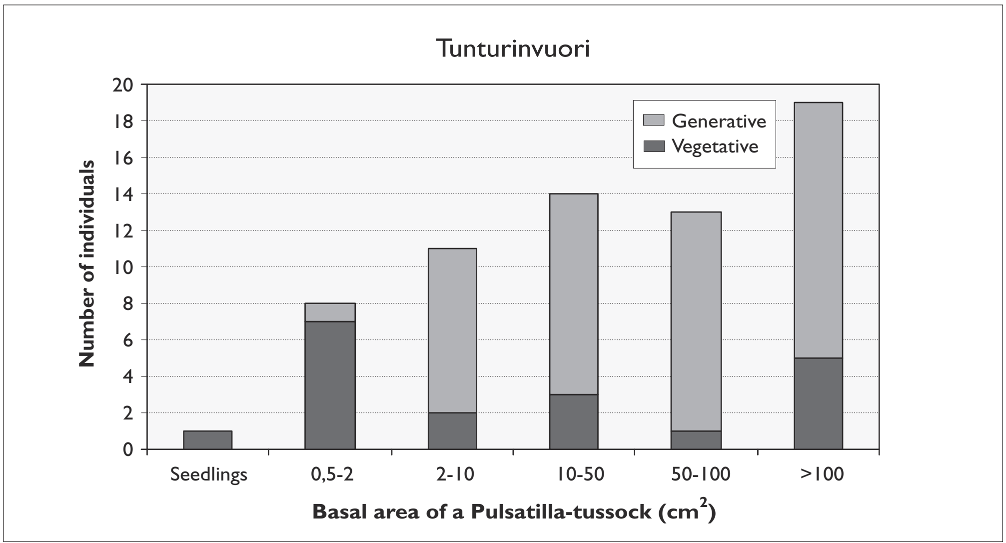


Figure 5. Size distribution of Pulsatilla patens *individuals in a stable population – an example population at Tunturinvuori, Finland. (Kalliovirta 2000)*

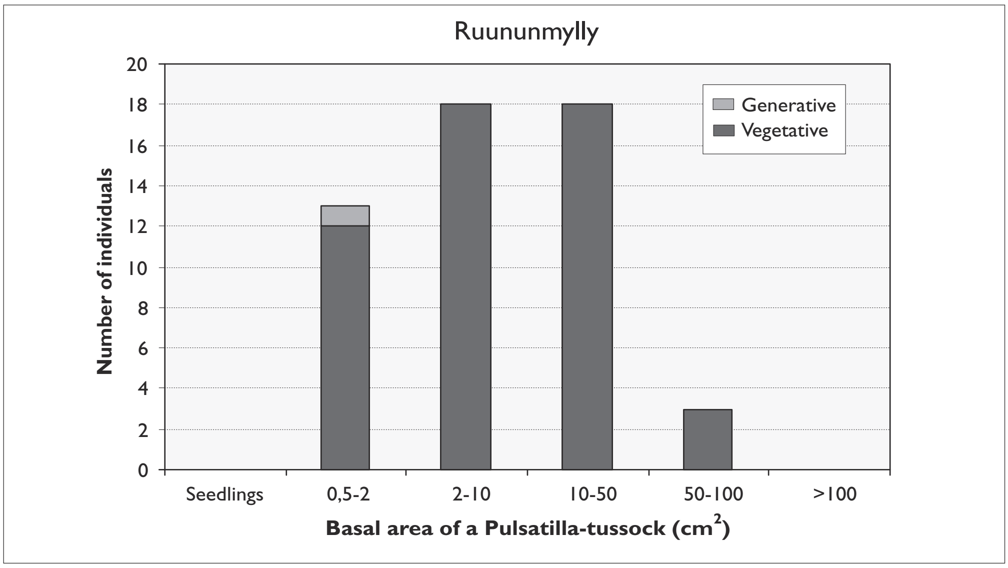


Figure 6. Size distribution of Pulsatilla patens *individuals in a decreasing population – an example population at Ruununmylly, Finland. (Kalliovirta 2000)*

changed. In stable populations, abundant flowering revealed the viability of adult individuals, and the proportion of flowering plants was typically high (averaging 27%). Some 57% of individuals were vegetative adults. The proportions of seedlings in stable populations averaged 15%.

Four populations out of 24 seemed to be decreasing. In populations interpreted to be declining, vegetative adults accounted for the vast majority (96%) of all individuals. The numbers and relative proportions of generative individuals were very low (only 1% of all individuals) and seedlings were usually completely absent (Fig. 6).

The relationship between environmental factors and population parameters

The clearest statistically significant correlations were observed between ground layer coverage and certain population parameters (Table 2). Ground layer coverage evidently influenced both the number of seedlings, and the proportion of seedlings.

More interesting results were achieved through the modelling described above. The key result was that the relationships between environmental and population variables were not linear, but clearly curvilinear. For example, both the total numbers of seedlings and the proportions of seedlings (% of all individuals) were highest when the ground-layer was semi-open. Also, the total number of individuals was highest at intermediate values for both ground and field layer coverage. (Kalliovirta 2000)

Table 2. Correlations between environmental and population variables in the Finnish *Pulsatilla patens* sites. (Kalliovirta 2000).

	Openness of the growth site	Ground layer coverage	Field layer coverage	Litter covergae	Total no. of individuals	No. of seedlings	Proportion of seedlings	No. of generative plants	Proportion of generative plants (% of adults)
Ground layer coverage	0.531***								
	0.000								
Field layer coverage	-0.018	-0.122							
	0.904	0.407							
Litter coverage	0.329*	0.160	0.104						
	0.023	0.277	0.481						
Total no. of individuals	-0.144	-0.283	0.188	-0.003					
	0.328	0.051	0.200	0.985					
No. of seedlings	-0.278	-0.379**	0.104	-0.119	0.750***				
	0.055	0.008	0.480	0.422	0.000				
Proportion of seedlings (%)	-0.261	-0.381**	0.072	-0.125	0.664***	0.973***			
	0.073	0.008	0.629	0.399	0.000	0.000			
No. of generative plants	-0.248	-0.330*	0.185	-0.192	0.741***	0.558***	0.483***		
	0.089	0.022	0.208	0.190	0.000	0.000	0.000		
Proportion of generative plants	-0.189	-0.252	0.109	-0.267	0.097	0.021	0.017	0.646***	
(% of adults)	0.197	0.084	0.460	0.067	0.512	0.890	0.909	0.000	
No. of flowers / generative plants	-0.218	-0.359*	0.008	-0.332*	0.314*	0.202	0.169	0.699***	0.793***
	0.137	0.012	0.957	0.021	0.030	0.169	0.252	0.000	0.000

Statistical significances: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Conclusions

The viability of populations can evidently be adequately assessed based on a single survey. However, surveying the population structure alone does not give the best results – largely because the size of a vegetative plant does not correlate well with its true stage or age. Plants of the same size may be either young or senescent. Instead, population structure analysis combined with information on environmental factors, especially the structure of the vegetation and the amounts of litter and shade, can make interpretations of the status of the population rather more reliable.

Sites with increasing populations are characterised by conditions where the demands of generative plants and seedlings are best met. This is the case in habitats with semi-open ground and field layers and sufficiently scarce litter. These conditions are not always optimal for flowering, but flowering usually remains regular enough to ensure seed production. In addition, favourable weather conditions (enough warmth and moisture) are needed for seeds to germinate. More studies are needed to determine the optimum overwintering conditions for the survival of seedlings.

Stable populations are generally found on well-lit sites where the ground layer is rather open and there is only relatively little litter. Generative plants thrive well in such conditions, and flowering is usually abundant. Dry conditions, which often prevail in open sunny slopes, tend to inhibit seedling development. The large quantities of seeds produced are thus mainly wasted, because seedlings have little chance of survival, although due to the vast amounts of seeds produced, even the small proportion of seedlings surviving to the adult stage is enough to ensure the regeneration of the population.

Closure of the ground and field layer reduces the viability and flowering of *Pulsatilla patens*. Increasing amounts of litter and thickening moss cover have a negative influence on both seedlings and adult plants, and may completely inhibit regeneration. In old and degenerating *P. patens* individuals, the numbers of flowers and leaf production both decline, resulting in reduced size. Regressive populations are consequently also characterised by the absence or relative shortage of large plants. The smallest populations were already excluded from this study during the planning of the research framework; and this partly explains the small number of regressive populations among the populations studied here. However, most of the small populations clearly represented the regressive population type, having no seedlings and only a few generative plants.

6.2.6 Overall conclusions

The monitoring regimes in Estonia and in Finland were carried out in very different ways. In Estonia, only a small sample of populations and permanent plots was examined. Population structure was studied at the level of life-cycle stages (vegetative, generative, juvenile plants). Many environmental parameters were estimated for these populations, but because of the small number of study populations, few conclusions could be drawn concerning the relationships between population parameters and environmental factors.

The Finnish study did not involve monitoring as such, since all the data was collected within a single growing season. The conclusions are therefore the result of comparisons between a high number of populations (about one third of all populations in Finland). No permanent plots were established in Finland. Fewer environmental characteristics were recorded than in Estonia, but the high number of sites enabled statistical analysis. Investigation of population structure was based on the size distributions of individuals, as well as on their life-cycle stages.

The Estonian study showed that the timing of monitoring is crucial in determining the true number of individuals in any population. If monitoring is timed to coincide with flowering, the presence of vegetative individuals may be completely missed. The ideal timing for monitoring is well after flowering, just when seeds are ripening. It is then possible to record the numbers of generative plants, the numbers and sizes of the vegetative plants, and possibly also the numbers of any juvenile plants that have survived from the previous season.

The monitoring of *P. patens* can be carried out either on permanent plots, or on the scale of the whole population. However, a set of permanent plots should be monitored demographically over a long time-scale to get a better idea of how individuals of *P. patens* fare in different circumstances. Permanent plots should also be established in Finland at ecologically different sites.

The most useful population parameters to record are: the numbers of generative, vegetative and juvenile individuals. If possible, the sizes of individuals (measured as the basal area of the tussock) should be measured. Flowering and seed production are also fairly easy to quantify by counting the number of flower stalks. Measuring the height of flower stalks did not give any useful information, however. Certain environmental parameters are important to describe, including the amount of open ground and litter, ground and field layer coverage, and the openness/shadiness of the site.

Where this long-lived perennial plant is concerned, general monitoring could be carried out at intervals based on the obligations of the Habitats Directive. Population surveys could be carried out at a representative sample of different sites every sixth year. A smaller selection of permanent plots could be monitored yearly using demographic monitoring over a longer period of time.

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6.3 Rhinanthus rumelicus *Velen. subsp.* osiliensis *Ronniger & Saarsoo*

English: Saaremaa yellow rattle
Estonian: Saaremaa robirohi
Finnish: Saarenmaanlaukku

Mari Reitalu

6.3.1 Introduction

Rhinanthus rumelicus subsp. *osiliensis* is of special interest as an endemic taxon in Estonia. It was discovered in 1933 by Bernhard Saarsoo in a spring fen in an area which today lies in the Viidumäe Nature Reserve (Saarsoo 1933). Saarsoo originally named the new plant as a separate species, *Alectorolophus* (syn. for *Rhinanthus*) *rumelicus* (Velen.) Borbás, but Professor Karl Ronniger from Vienna subsequently identified it as a new subspecies endemic to the island of Saaremaa – *Rhinanthus rumelicus* Velen. subsp. *osiliensis* Ronniger et Saarsoo (Ronniger 1934).

The Saaremaa yellow rattle subsequently attracted attention thanks to Karl Eichwald, who gave evidence for classifying it as a totally separate species (Eichwald 1960). Nevertheless, the species was named *Rhinanthus osiliensis* (Ronn. et Saars.) Vass., and Eichwald was not mentioned as an author since his studies had not been published in time (Kask 1981). The Saaremaa yellow rattle was subsequently recorded as *Rhinanthus osiliensis* in the Flora of the Estonian SSR (Kask 1969) and in many other floras (e.g. Leht 1999), although more recently it has again been treated as a subspecies of *Rhinanthus rumelicus* (Kukk 1999).

Rhinanthus rumelicus subsp. *osiliensis* has been protected in Estonia since 1958, and today belongs to the II category of protected species (see page 14). The plant is listed in the Red Data Book of Estonia as "rare", in the Red Data Book of Baltic Region as "endangered" and in the IUCN Red List of Threatened Plants (1997) as "endangered". It has also been listed in Annexes II and IV of the EU Habitats Directive since 2002. About 60% of the total population of *Rhinanthus rumelicus* subsp. *osiliensis* grows in protected areas – in the Viidumäe Nature Reserve and the Vilsandi National Park. Under the Natura 2000 Program seven more reserves are planned to protect *Rhinanthus rumelicus* subsp. *osiliensis* habitat, meaning that 95% of the population could eventually be protected.

6.3.2 Characteristics

Rhinanthus rumelicus subsp. *osiliensis* is an annual herb with a height of 10–50 cm. The upper part of the upright stem is often ramified, and marked with short dark purplish longitudinal lines. Lineal leaves are serrated. Flowers are light yellow, with corolla up to 2 cm long. The flower's mouth is almost closed, and its upper lip has a dark violet tooth. *Rhinanthus rumelicus* subsp. *osiliensis* can be distinguished from other *Rhinanthus* species in Estonia by its glandular hairs, which although light and difficult to discern, can be found mostly in the upper part of the plant – on the stem, leaves, bracts, calyx, corolla, and even on capsules. These glandular hairs were already noticed by Saarsoo, indeed it was this feature that made him suspect that he had discovered a new species.

6.3.3 Distribution and ecology

Rhinanthus rumelicus subsp. *osiliensis* is an endemic taxon in Estonia, where its distribution is restricted to western and north-western parts of the island of Saaremaa. The distribution of *Rhinanthus rumelicus* subsp. *osiliensis* was first surveyed in 1937–1938, when the species was first discovered (Saarsoo 1938). K. Eichwald later compiled a distribution map based on Saarsoo's data and his own later surveys (Eichwald 1960, 1965). These old localities have been revisited more recently to produce a more up-to-date distribution map, and the plant is today thought to occur in seven survey quadrants (6 km x 10 km) in western Saaremaa. In 2000–2001, all 31 known localities were again surveyed in order to evaluate the overall state and approximate size of the population, and to find out which habitats are in the best condition. The plant has survived in all the major occurrences noted in the 1930s, but in many cases it has been impossible to find former localities on the basis of inaccurate descriptions or due to major changes in landscapes.

Rhinanthus rumelicus subsp. *osiliensis* has disappeared from three localities where it was still found in the 1960s, evidently due to habitat change (overgrowth, drainage). Its total population now numbers approximately 26,000 individuals, about half of which grow in the Viidumäe Nature Reserve, near where the first specimens were identified. Saarsoo named spring fens as the plant's main habitat and mentioned moist wooded meadows as being less important. The spring fens at the foot of the former coastal escarpment of the ancient Ancylus Lake in Viidumäe are still preferred habitats.

Spring fens are characterised by mosaic micro-relief, and a special set of microclimatic, humidity, and soil conditions. The peat in such habitats is formed of sedges, reed, and mosses in a moderate or advanced state of decomposition. The peat horizon is 30-100 cm thick, and has a pH of varying from 6.0 to 7.0. The grass layer is characterised by *Schoenus ferrugineus*, *Carex hostiana*, *Carex panicea*, *Carex davalliana*, *Sesleria caerulea*, *Primula farinosa*, *Tofieldia calyculata*. Several other species that are protected in Estonia are also quite common in such sites – including *Juncus subnodulosus*, *Pinguicula alpina*, *Gymnadenia odoratissima*, *Dactylorhiza russowii*. Characteristic moss species are *Drepanocladus cossonii*, *Campylium stellatum*, *Bryum pseudotriquetrum*, *Palustriella commutata* and in some places *Scorpidium scorpidioides.*

As well as being associated with spring fens, *Rhinanthus rumelicus* subsp. *osiliensis* can be found in species-rich fens with various water regimes, and in paludified meadows. Moist wooded meadows no longer form suitable habitats for the species due to overgrowth; but the plant can occasionally be found on the sides of ditches and brooks, on moist forest roads, roadsides and in roadside ditches – although in these habitats it typically only grows for some time, and then disappears.

The most important of the factors endangering *Rhinanthus rumelicus* subsp. *osiliensis* habitats is the possible drainage of fens and paludified meadows. Where such areas are significantly drained to create sown meadowland, the plant's habitat will be destroyed. Even less pronounced drainage can harm the prospects for the species indirectly in the long run, by accelerating bog formation. The drainage of paludified meadows usually contributes to their overgrowth.

6.3.4 Biology

Like other *Rhinanthus* species, *Rhinanthus rumelicus* subsp. *osiliensis* is a semi-parasitic plant. The hosts for rattle species are mainly perennial herbs, often grasses. No special study has been conducted for the Saaremaa subspecies, but considering the species composition of its habitats, the host could be a sedge or a grass.

Long-term phenological observations at the Viidumäe Nature Reserve have revealed that sprouting usually takes place in late April or early May. Further development is slow, so flower buds do not appear until the second half of July, by which time *Rhinanthus minor* L. has fruited already. Full blooming occurs in late July or the first two weeks of August – and in some years even later. Full blooming can occur up to two weeks earlier in well-lit sites than in shady sites. Some flowering specimens may even be observed in the second half of September. Fruits ripen by the end of September, or occasionally in the beginning of October. Fruiting is usually successful: productivity on a scale of 1 to 5 is seldom rated at less than 4–5. Plants have usually already dried up by the time seeds begin to spread. Autumn frost damage has not been observed.

Rhinanthus rumelicus subsp. *osiliensis* is pollinated by insects and seeds are windblown (Eichwald 1965). Some of the seeds do not spread very far from the mother plant, and new seedlings can typically be found in the neighbourhood of the previous summer's dry stem. Seeds can usually germinate only for one year, so the *Rhinanthus rumelicus* subsp. *osiliensis* seed bank is not permanent.

6.3.5 Monitoring methods

Monitoring of *Rhinanthus rumelicus* subsp. *osiliensis* began in 1994, when the Estonian state monitoring programme was started up. Two sites in the Viidumäe Nature Reserve, about 2.7 km apart, are monitored using the plot monitoring method. In Estonia, annual plants are monitored over monitoring rounds of three years, with five years between rounds. The first monitoring round was conducted in the period 1994–1996, and data from the current monitoring cycle is available for 2001 and 2002. Additional data is available for 1999–2001 from a separate monitoring plot set up for monitoring *Dactylorhiza russowii*, where *Rhinanthus rumelicus* subsp. *osiliensis* also occurs.

In 1999, the monitoring of Estonian rare plant species was complemented with status monitoring; and the Saaremaa yellow rattle was selected for status monitoring at twelve sites in 2000–2001 (Table 1).

Information has also been available on trends in the occurrence of *Rhinanthus rumelicus* subsp. *osiliensis* in a vegetation community monitoring site in the Viidumäe spring fen. This site consists of a 50 m x 50 m plot where vegetation is analysed in twenty squares of 1 m².

The conclusions below are also based to some extent on data and experience obtained from long-term nature observations in the Viidumäe Nature Reserve.

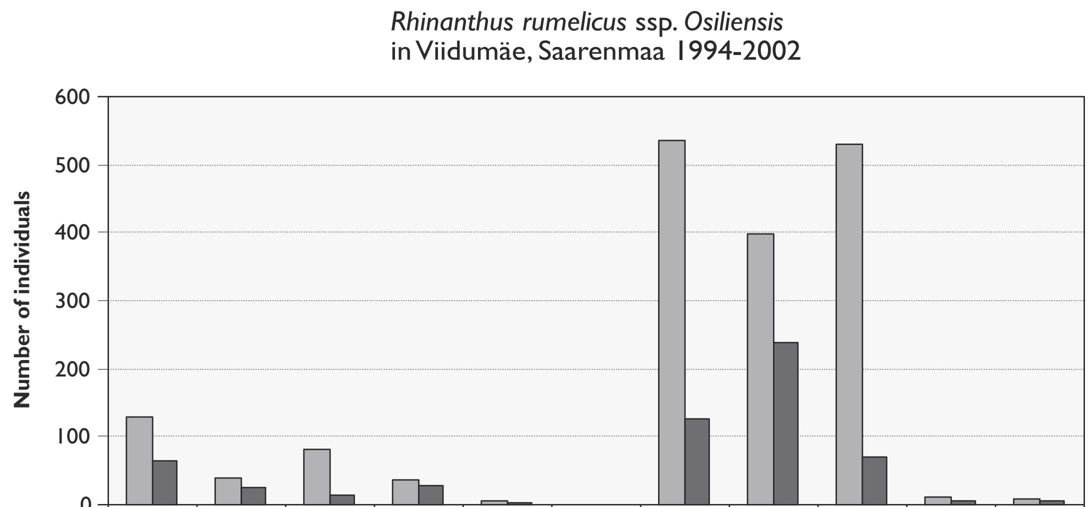
6.3.6 Results and analysis

Plot monitoring

One monitoring plot is situated in a small glade in sparsely forested spring fen alongside a springy brook. In 1987, fifty *Rhinanthus rumelicus osiliensis* plants were found in the whole site; but by 1994 when monitoring started, the plants' numbers had increased to 320, and the population remained relatively stable during the first monitoring cycle (1994–1996). By 2002, the population had dwindled to 29 specimens. Similar trends were observed inside the monitoring plot (Fig. 1). In 1994, plants were observed growing in 45 survey squares of 1 m², but in 2002 they were only found in 6 squares. During the first monitoring round, it was noted that many plants were damaged, evidently by deer, insects or fungi. Badly damaged plants fruited very late, or not at all. This damage probably explains why this local population has subsequently declined so much. Only a few specimens growing right beside the brook in better light conditions had maintained their vitality.

The other plot is situated on a site where the species has occurred since at least 1966. The plot is in a wide, almost open spring fen. The size of this local population has fluctuated greatly, between 1,500 and 4,300 individuals during the monitoring period. Major changes were also observed inside the monitoring plot: the number of specimens decreased from 535 in 1994, to 8 in 2002 (Fig. 1), and the number of 1 m² survey squares where the species was found declined from 89 to 8. The reasons for the high population density observed in the beginning of the monitoring period remain unclear. The factors behind the plant's decline appear to be the same as those noted above for the other monitoring plot. One additional factor restraining successful reproduction could be that densities were too high here,– as since the plants were growing very tightly together, they remained low (only 5–10 cm), producing few flowers, and only blooming late.

A monitoring plot primarily established for the monitoring of *Dactylorhiza russowii* in a lime-rich fen in Viidumäe Nature Reserve contained seven *Rhinanthus rumelicus osiliensis* specimens found in three 1 m² survey squares in 1999, 18 specimens in 11 squares in 2000, and 19 specimens in 10 squares in 2001. Additional comparative data will be available from this plot during in the next monitoring round (2006–2009).



	1994	1995	1996	2001	2002		1994	1995	1996	2001	2002
Total no. of plants	128	40	81	36	7		535	398	530	10	8
No. of damaged plants	64	24	14	27	4		126	238	70	5	7

Figure 1. Abundance of Rhinanthus rumelicus *subsp.* osiliensis *in two monitoring plots in Viidumäe (1994–2002).*

Status monitoring

Status monitoring for *Rhinanthus rumelicus* subsp. *osiliensis* was conducted in 2000 and 2001 at 12 sites outside the Viidumäe Nature Reserve. Eight of these sites are amongst the plant's ten most vital and abundant populations, and growth conditions are optimal in these sites (Table 1). At four smaller sites (population size 5–45 individuals) plants were observed growing in occasional habitats – on the edge of a ditch, and beside or actually on a forest road.

Community monitoring

In 1999, vegetation community monitoring was conducted in a spring fen near the *Rhinanthus* monitoring plot, and *Rhinanthus rumelicus* subsp. *osiliensis* was found in 5 of the 20 survey squares.

Table 1. Data on the ten largest and most vital populations of *Rhinanthus rumelicus* subsp. *osiliensis* in Estonia (from 2000–2001).

Locality	Size of population (No. of individuals)	Habitat	Habitat conditions	Endangering factors	Monitoring
Viidumäe Nature Reserve	12,000	Spring fen, species-rich fen, paludified meadow	Mostly optimal	Drainage nearby accelerates bog formation	Two plot monitoring sites (1994-1996; 2001)
Paatsa fen	2,100	Spring fen	Optimal	On edge of habitat, becoming overgrown with bushes	Status monitoring 2001
Vesiku, Vilsandi National Park	2,000	Species-rich paludified meadow, spring fen	Negative influence of off-road traffic	Intrusion of reeds, uncontrolled use of road	Status monitoring 2001
Oju, Vilsandi National Park	1,000	Species-rich paludified meadow	Optimal	On edge of habitat could become overgrown with bushes	Status monitoring 2001
Tehu fen	500	Species-rich fen	Optimal	No threats observed	Status monitoring 2000
Shore of Lake Tehu	500	paludified meadow	continuous over-growing of the lake enlarges habitat	Tall grasses increasing along ditches	Status monitoring 2000
Haavassoo	500	Spring fen	Optimal	Drainage may promote overgrowing	Status monitoring 2001
Lümanda Suurissoo	5500	Paludified meadow	Reproduction especially successful due to shallow soil cover	Lacking if present land-use continues	Status monitoring 2001
Vahtrissoo	300	Species-rich spring fen, in places paludified meadow	Still optimal	Drainage nearby could dry out spring fen	Status monitoring 2001
Viidu fen	300	Species-rich fen	Optimal	Regulation of water regime near road	

6.3.7 Conclusions

1. Populations of annual plants can be short-lived, even in optimal conditions (as in the first monitoring plot). The size of the population increased approximately six-fold over the period 1987–1994, but then decreased rapidly until 2002. The endangering factors were natural, and it would not be possible or desirable to act in any way here to protect the species. Status monitoring should be sufficient to determine whether and how quickly this population recovers, and laborious plot monitoring is not absolutely necessary.
2. It is important to observe the state and abundance of a species over the whole site, rather than just in the 10 x 10 m monitoring plots, because the growth sites of annual plants may change quite quickly within populations (as was noted in the second monitoring plot), even where there are no significant changes in the overall population size. The plot monitoring method could also be replaced by status monitoring at the second monitoring site, while another option would be suitable improvements to vegetation community monitoring procedures.
3. During further monitoring of *Dactylorhiza russowii* in the plot described above, the occurrence and abundance of *Rhinanthus rumelicus* subsp. *osiliensis* should also be recorded.
4. Status monitoring sites need revisiting in both optimal and occasional habitats. The best interval for status monitoring could be five years, depending on the results of plot monitoring.
5. The biology of *Rhinanthus rumelicus* subsp. *osiliensis* is still poorly understood. Monitoring procedures could be expanded in order to learn more about the species' biological characteristics. It should be possible to gather additional material during monitoring in order to ascertain which species serves as its host, and to determine which insect and fungus species damage the plants. Existing monitoring data can also be used for these purposes.

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6.4 *Ligularia sibirica* (L.) Cass.

English: Siberian Groundsel
Estonian: Harilik kobarpea
Finnish: Siperiannauhus

Ülle Kukk

6.4.1 Introduction

Ligularia sibirica is one of the most threatened plant species in Estonia. The plant now only occurs in about half as many localities as it did a few decades ago. The majority of its occurrences are seriously threatened by human activities, even though they are all protected. Monitoring has been started in all the eight sites where the species occurs, with plot monitoring started in four sites.

Ligularia sibirica is included in the Red Data Book of Estonia in Category 1 (endangered). The species has been protected since 1936, and since 1994 has been protected in Category I (strictly protected) (Kukk 1999). The objective of this monitoring was to assess:

- population sizes
- changes in population sizes over time
- any changes in density
- any changes in viability
- changes in the plant's habitats
- how management measures impact on populations

6.4.2 Biology

Ligularia sibirica is a stout 100–170 cm tall perennial from the family Compositae. The rhizome is short and thick; and stems are erect, and occasionally branched. Its lower leaves are kidney-shaped, long-stalked and sheathed at the base, up to 30 cm across, and all toothed; while the upper leaves are much smaller and stalkless. The numerous gold-yellow flower heads form a spike-like cluster 15–70 cm in length with 10–30 heads per cluster. Achenes are 5–6 mm long, with a pappus consisting of brownish-white hairs.

Leaves begin to grow in the end of April or the beginning of May. *Ligularia sibirica* flowers in the end of July and in August. Its seeds ripen in the end of August or in September, and are usually dispersed by wind, although dispersal by animals is also possible. Data on the ability of seeds to germinate is inconsistent: experiments in Estonia indicated that seed germination rates are low (Institute of Forestry and Nature Conservation, Tartu, 1984), although data from the Czech Republic gives higher rates (Procházka and Pivničková, 1999). Vegetative reproduction is possible, but ineffective, because of the limited growth rate of the rhizome, about 6 mm per year (Sammul, unpublished). Consequently, *Ligularia* usually grows in clumps of 2–5 perennial ramets. Ramifying of the rhizome is connected to flowering. A new bud forms on the rhizome of a flowering ramet. The life span of a genet can be about 10 years. Further studies are still needed to determine the ontogenesis and biology of *Ligularia*.

Typical habitats of *Ligularia sibirica* include paludified grasslands and scrubland, forest plains, minerotrophic fens, spring fens and floodplain grasslands. The plant can survive in more open habitats, but suffers in increasing shade, as firstly flowering and then fruiting cease. Semi-open patches near shrubs and trees seem to be favoured. This phenomenon is probably related to former land uses: the only sites that escaped the active grazing and mowing of grasslands in the early 20th century were the edges of scrub. It is not known whether soil acidity is a factor in its occurrence, and in Central Europe the plant occurs in both alkaline soils (Šegulja and Krga, 1990) and acidic soils (Procházka and Pivničková, 1999). Very little information is available about the corresponding soil types in the plant's habitats in Russia and Asia. In Estonia, the species' habitats in most cases have acidic soils. Soil types have been determined according to the vegetation present, rather than any special investigation of the soil.

6.4.3 Distribution

Ligularia sibirica is widely distributed across continental Eurasia. In Europe, its distribution is largely eastern, with occurrences in Latvia, Poland, the Czech Republic, Slovakia, Austria, Yugoslavia and France, although it is very rare in each of these countries. In Russia, it is very rare in the Murmansk and Pskow regions, but fairly common in the Leningrad and Karelia regions. In Estonia, *Ligularia sibirica* occurs on the north-western edge of its continuous range. It is not found in Finland, Scandinavia, Lithuania or other countries in central and western Europe.

Ligularia sibirica is today only found in eight sites in Estonia, and has disappeared from around half of the localities where it was formerly found. Several of the surviving populations are themselves very small and threatened. Several occurrences have disappeared due to changes in land use or for unknown reasons. These eight remained sites are mainly located in eastern and southern Estonia. Four sites are near the town of Tartu: two on the floodplain grasslands of the River Emajõgi (the Anne and Kikaste sites), and two in scrubland near the River Amme north of Tartu (the Väägvere and Sootaga sites). The two sites in southern Estonia (Tagula and Õisu) contain the largest populations; and there are also two sites in northern Estonia (Jõhvi and Kukruse).

6.4.4 Monitoring methods

Four sites (Anne, Sootaga, Väägvere and Tagula) have been monitored using the plot monitoring method over the period 1994–2002 at intervals of 1–3 years. Data was collected 3–7 times for each site. The recorded parameters included the total number of tussocks in the population; the total number of vegetative, generative, and juvenile plants on the plot; the number of shoots per tussock; the locations of tussocks on the plot; and the height and viability of the plants. The population indexes used below express the number of tussocks found subsequently in comparison to the first monitoring session (in percentage terms; first monitoring = 100%). These indexes were adopted for the comparison of data from the monitoring plots, and for data from whole populations.

The four populations at the Kikaste, Kukruse, Jõhvi and Õisu sites were also surveyed in 1996, 2001 and 2002 using status monitoring.

6.4.5 Results

The sites

The habitat type at the Anne site is poor paludified grassland. The vegetation has changed noticeably over the last seven years. Several new hemerophilous species (e.g. *Artemisia* ssp., *Urtica dioica, Rubus idaeus*) have invaded the site – probably due to man-made fires spreading in the withered grass in spring. Signs of human activity (construction, drainage ditches) are obvious, and have evidently been present for the last thirty years. Mowing has ceased, and habitat is becoming overgrown with shrubs and trees. At the Väägvere site, floodplain willow scrub dominates, and the area is becoming overgrown with shrubs and forest trees. In the herb layer, *Phragmites communis* and *Calamagrostis canescens* are increasing. Competition from tall herbs/graminoids and has also reduced the availability of light. The habitat type at the Sootaga site is a paludified *Filipendula*-dominated birch forest. The first signs of overgrowing were noticed during the latest monitoring in 2001. The Tagula site is dominated by *Filipendula* birch forest alongside a *Geranio palustris-Filipendula* spring fen. The herb layer is lush and species-rich, but the first signs of overgrowing by willows are evident. Nevertheless, the current light-shadow conditions still seem to favour *Ligularia sibirica*. The sites where smaller populations are found consist of paludified or floodplain meadow in a transitional stage towards becoming forest.

The populations

A total of approximately 1,500–1,600 tussocks were found in Estonia, with 90 % of them growing in three localities (Sootaga, Õisu and Tagula); and plants in these populations were not counted exactly, because they were so numerous. The smallest populations (Jõhvi and Kikaste) each consist of fewer than ten individuals. (Table 1).

Table 1. Sites and monitoring periods for *Ligularia sibirica* in Estonia.

Site	Total size of population, first and last monitoring	Total no. of tussocks on the plot, first and last monitoring	Habitat	Years of first and last monitoring
Anne	111 – 29	35 – 6	Poor paludified grassland, overgrown and burnt	1994 – 2002
Väägvere	96 – 42	30 – 19	Floodplain willow scrub, accelerated overgrowing	1994 – 2001
Sootaga	~500	94 – 56	Paludified forest, Filipendula birch forest.	1996 – 2001
Tagula	~400 – 600	93 – 331	Filipendula birch forest, near spring fen	1994 – 2000
Õisu	3 – 6 + ~400		Ditch near fresh forest. Floodplain forest	1996 – 2002
Kikaste	5		Floodplain forest	2001
Kukruse	15 – 52		Wooded meadow, becoming overgrown by shrubs and trees	2001 – 2002
Jõhvi	10 – 2		Paludified forest, pronounced human impact	2001 – 2002

At the Õisu site, a new vital sub-population was found in 2002, about 200 metres downstream of the plants monitored earlier. At the Kukruse site, the number of plants has apparently increased, probably due to more thorough surveying in 2002 (some plants were evidently not discovered in 2001). The total numbers of plants have declined steeply at the Anne, Väägvere and Jõhvi sites. At the Anne site, the decrease was especially pronounced between 1994 and 1997.

Monitoring-plots were established for four populations. The idea was to examine whether the data collected from the plots is representative for the whole population. The population indexes for the whole population and for the plot at the Anne site are presented in Fig. 1. The indexes correlate positively with the whole population data in most cases, except for 1997 when there was a considerable discrepancy. Over the period 1994 to 1997 the total number of plants diminished significantly, but on the monitoring plot the most pronounced decline only occurred the following year. This decrease subsequently continued in both cases, but became less pronounced.

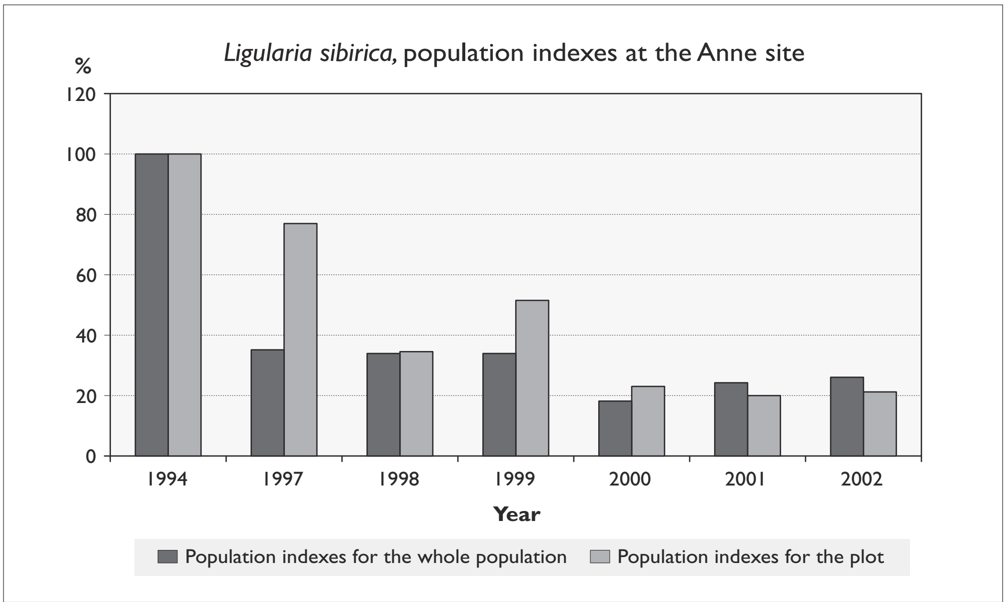

Figure 1. Population indexes for Ligularia sibirica *at the Anne site, Estonia.*

Population indexes of 130, 150 and 63 recorded at Väägvere exhibit considerable fluctuations. The Sootaga site was monitored three times, giving population indexes of 86 and 60. At the Tagula site, population indexes of 169 and 356 indicate a clear increasing trend. In spite of some fluctuations at Anne and Väägvere, populations have evidently decreased everywhere except Tagula.

Population densities (tussocks/m²) varied between 0.06 tussocks/m² (minimum at Anne site 2002) and 3.31 tussocks/m² (maximum at Tagula site 2000). In the four populations examined, population densities had continuously declined during the monitoring period everywhere except Tagula, where the most viable and largest population proliferated during the monitoring period (Fig. 2).

Population structure has been described on the basis of the relative abundance of plants at different life cycle stages (generative plants, vegetative adults and juveniles). At the Anne and Sootaga sites, the numbers and/or proportions of flowering plants have decreased (Fig. 3 and 4). At Väägvere, flowering ceased in 2001. At Tagula, the ratios between juveniles, vegetative and generative specimens have remained stable, indicating that sexual reproduction is continuing, as well as vegetative reproduction via the ramification of rhizomes. Some tussocks are quite dense and consist of numerous shoots, making it hard to discern whether the tussock consists of one individual or several individuals growing densely together.

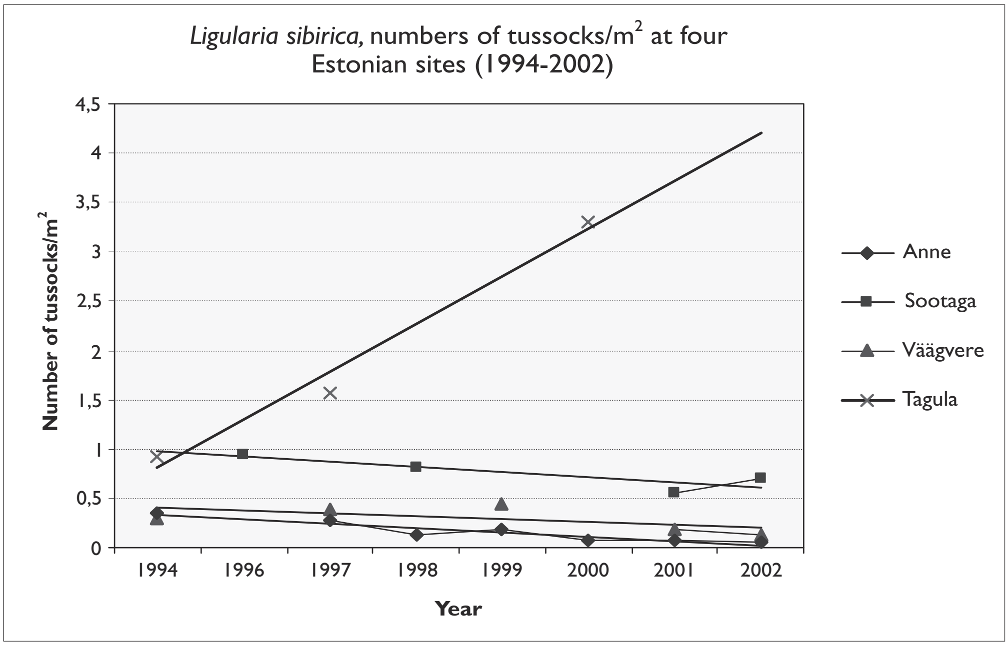

Figure 2. Numbers of Ligularia sibirica *tussocks per square metre at four Estonian sites (1994–2002).*

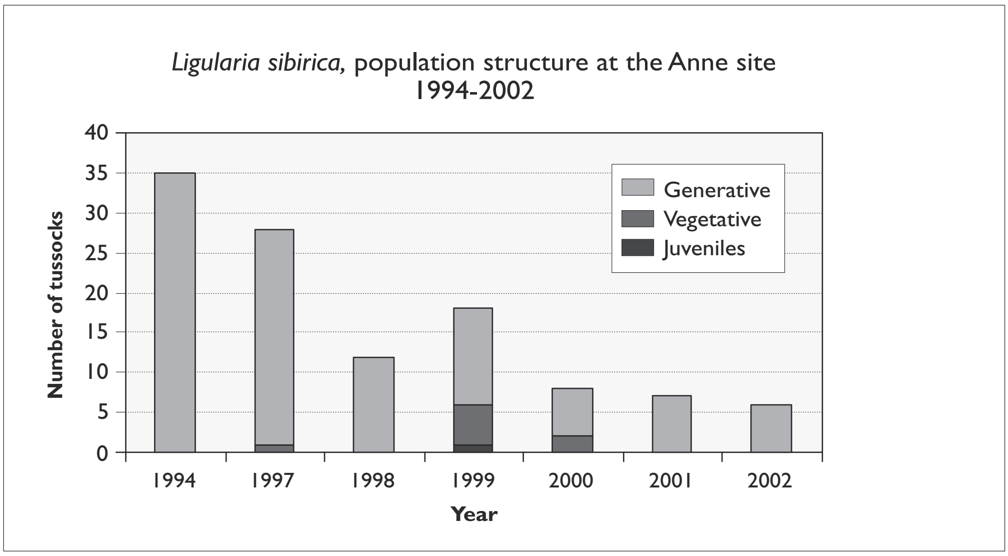

Figure 3. The proportions of plants at different life cycle stages in a decreasing Ligularia sibirica *population (Anne site, Estonia).*

Plant sizes may reflect the viability of individuals. The heights of flowering shoots were measured, and the numbers of shoots counted for every tussock. The tussocks were divided into height classes, and the proportions of plants in the various height classes are shown in Figures 5 and 6.

The shoots of plants at the Anne site have been tall for many years, but they have been steadily decreasing in size. At Väägvere, plants have mainly been 79-85 cm tall, without any fundamental changes. The heights of flowering shoots at the Sootaga site have varied between 50 and 125 cm, with no notable changes. Average shoot heights at the Tagula site have always been lower than at Väägvere.

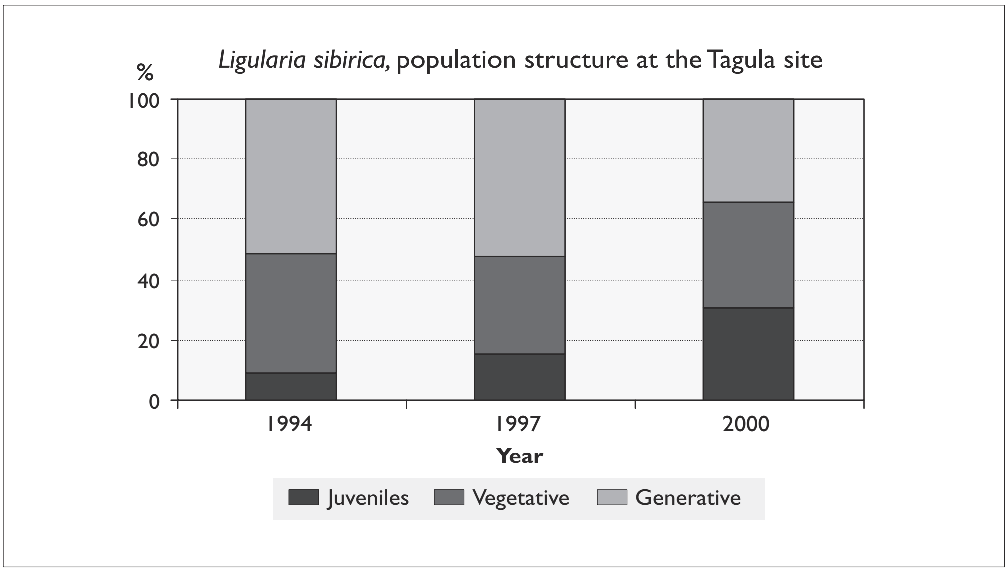

Figure 4. The proportions of plants at different life cycle stages in an increasing Ligularia sibirica *population (Tagula site, Estonia).*

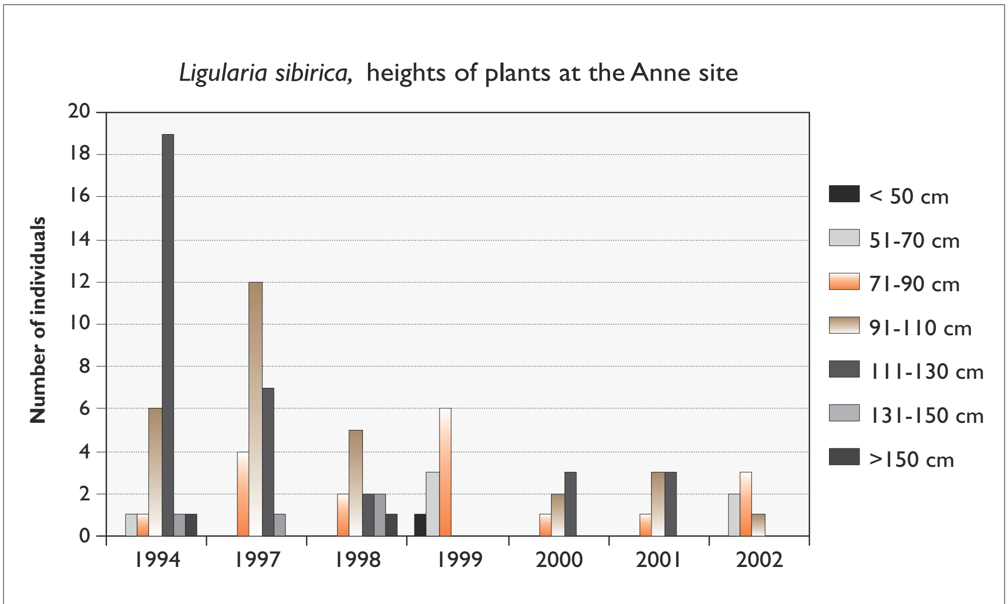

Figure 5. Height distribution of plants in a decreasing Ligularia sibirica *population (Anne site, Estonia).*

The number of shoots per tussock declined at the Anne site during the monitoring period 1994–2002. Nearly 60% of all tussocks had more than 10 generative shoots in 1994; but by 2001, none of the tussocks reached this size, and only two plants had 6–10 generative shoots. In 2002, one tussock consisted of 11 shoots (Fig. 7.).

Disease and damage were only observed at the Anne site, where stems exhibited damage due to fungal diseases, and leaves had suffered from insect and snail damage.

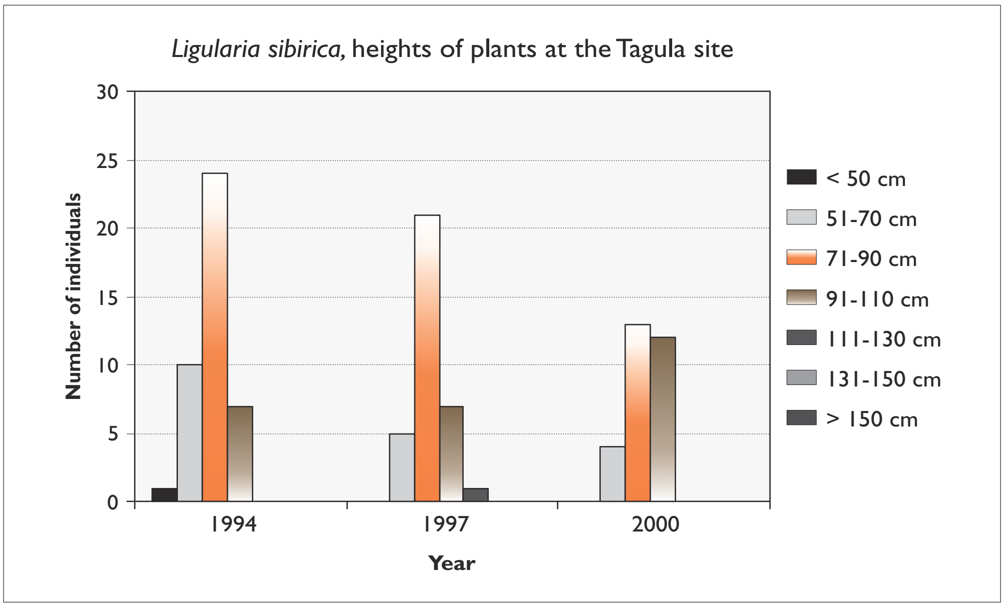

Figure 6. Height distribution of plants in an increasing Ligularia sibirica *population (Tagula site, Estonia).*

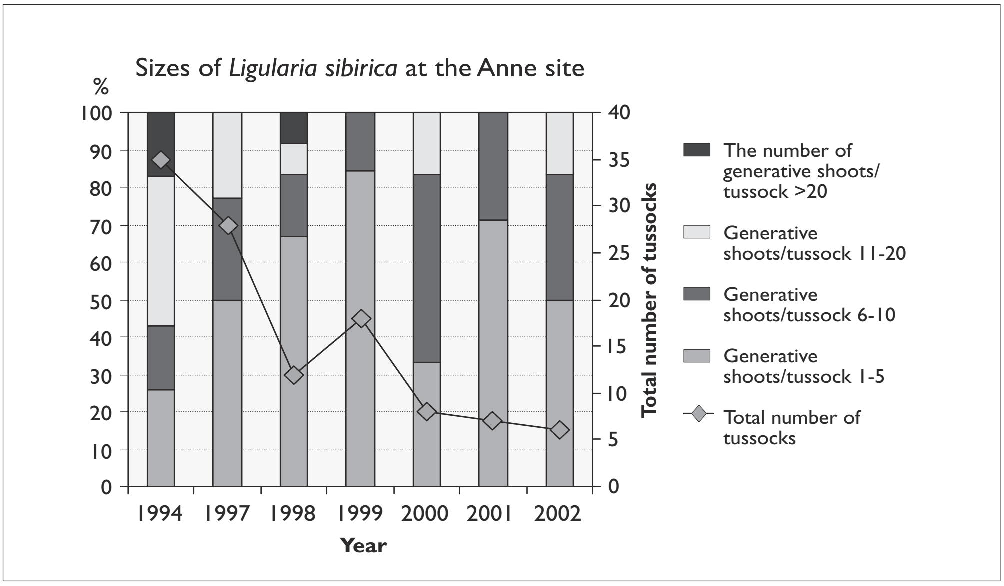

Figure 7. Size distribution of Ligularia sibirica *plants (Anne site, Estonia).*

6.4.6 Conclusions and proposals

In Estonia, *Ligularia sibirica* only grows at eight sites, even though there is plenty of suitable, unoccupied habitats still available. The species is not showing any tendency to expand its distribution in Estonia; on the contrary, it has disappeared from almost half of the localities where it was previously known. The fact that Estonia lies on the western extreme of the species' range may be one reason for its scarcity and its apparent decline.

The majority of the remaining populations are continuously decreasing in size and density. The structures of these populations have been steadily changing in recent years, showing an increase in the number of vegetative plants, and a corresponding decrease in the numbers of flowering plants and juveniles. This indicates that seed production and sexual reproduction are becoming less effective. Vegetative reproduction via the ramification of rhizomes is continuing in at least some sub-populations, but this only occurs seldom, and is not an effective way of regeneration.

Considering the population sizes and structures of *Ligularia sibirica*, only three populations currently seem to be viable, stable and capable of reproduction. The other five populations can all be classified as regressive, with the numbers of individuals decreasing, and no successful reproduction evident.

This rapid decline seems to be due to the gradual overgrowth of habitat with shrubs. This process is occurring in most of these localities, and some sites are also affected by melioration and contamination. The impact of these developments on vegetation and light conditions is clearly evident.

The population of *Ligularia sibirica* at Anne is acutely threatened, and habitat management is urgently needed. Management started in 2000, with thinning and mowing carried out in 2000 and 2001. The condition of the population at Väägvere is worsening, due to increased forestation. Thinning is necessary here, too, and the local environmental department started habitat management work in 2001. The population at Sootaga is larger than those at most of the other sites, but habitat management, in the form of thinning, was also started here in 2001. The *Ligularia sibirica* populations at the Tagula site are the most thriving populations in Estonia. High numbers of individuals and high densities indicate that the population is clearly viable, with regeneration by sexual reproduction enabling the population to expand. Tagula is the only site where the situation has improved during the monitoring period. The population at Õisu seems to be increasing at the existing monitoring site, although management measures are needed to improve light conditions. The recently discovered sub-population seems to confirm that the population at Õisu is indeed also viable. Restoration of the sub-population at Kikaste may be possible, but this would involve considerable effort and expense. The Jõhvi site is located close to the local rubbish dump, and is therefore badly contaminated, so the restoration of this site is very problematic. Meadowland at the Kukruse site is becoming overgrown with shrubs, and growth conditions have become unfavourable due to increasing shade. Habitat restoration at this site would also be complicated and expensive.

Methodological issues

1. Collecting data on whole populations is time consuming, and only possible for small populations. The data obtained from the Anne site indicates that data from monitoring plots can give generally representative and comparable results.
2. Population indexes can be very suitable for comparing the changes occurring in different populations. Such indexes can be much easier to compare than absolute quantities.
3. The sizes of tussocks and the heights of generative shoots were used as parameters reflecting the viability of populations and individual plants. Measuring plant sizes may give interesting information when assessing changes in a population over longer time periods. When comparing different populations, however, local ecological factors may explain most of the variations in morphological measurements between populations.
4. It is vital that other vegetation is described in detail, since any wider changes noted in vegetation communities may help to explain changes in the population of the target species.
5. Defining the locations of individual tussocks within plots by using co-ordinates was found to be unreliable. Where monitoring individual plants, the plants should preferably be marked.

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6.5 *Agrimonia pilosa* L.

English: 'Chinese Agrimony', 'shaggy speedwell'
Estonian: Karvane maarjalepp
Finnish: Idänverijuuri

Eija Kemppainen and *Malle Leht*

6.5.1 Introduction

Agrimonia pilosa, like many other species in this genus, has been widely cultivated as a medicinal plant. In its western distribution area, in Fennoscandia and Estonia, the species seems to be of an archaeophytic origin, although Linkola (1921) considered it as a native of the region around Lake Ladoga. There is no information on the traditional medicinal use of *Agrimonia* in Estonia; but in Finland flowers of *A. eupatoria* in particular have been used for tea, and its roots have been used for medicinal purposes (Linnilä et al. 2002). It also seems that *A. pilosa* only spread into Estonia quite recently, as the plant has no local idiomatic names, unlike other species which have hundreds of them. The species' present occurrences in villages and yards, along paths and roads, and on the margins of former pastures, indicate that it has spread in close connection with human activity. This means that the protection of this species and the conservation of its growth sites involves preserving our natural heritage, as well as protecting biodiversity.

A. pilosa is listed in the Habitats Directive of the European Union. In Finland, the species is considered as endangered (EN; Rassi et al. 2001). Its decline in Finland is due to the end of traditional grazing in forests and semi-natural grasslands. Old pastures and meadows have widely either been deliberately forested, or abandoned and become overgrown. In Estonia, *A. pilosa* is protected in Category III (see page 14), although it is not listed in the Estonian Red Data Book.

A. pilosa was a target species for a research project examining the population biology of four threatened species in Finland during the period 1987–1989 (Lahti et al. 1991, Uotila et al. 1990). The results of this monitoring and some small management experiments have been published in Finnish (Kemppainen et al. 1993), and some of this data has also been used here. Monitoring has subsequently been continued on the basis of this project almost yearly from 1990 to 2002. In Estonia, *Agrimonia pilosa* populations at two monitoring sites were examined in 1999 by Malle Leht and in 2001 by Ülle Kukk. The state of 45 other populations was surveyed and described in 2001 and 2002 by Malle Leht.

6.5.2 Distribution

The wide continental distribution of *Agrimonia pilosa* stretches from Finland and Hungary to Mongolia, Japan and South-east Asia. In the Leningrad District and Karelia the species is considered rare.

Within Estonia, *Agrimonia pilosa* mainly grows in the southern part of the country; few localities are known in central or northern Estoniaa; and the species is virtually absent from the west. In the Estonian flora-database *A. pilosa* has been recorded in 86 squares (10 km x 10 km): although it has not been observed since 1971 in 40 of these squares. Although the species was described in Estonia as long ago as 1823, the first available herbarium sheets are from 1848.

In Finland the species has been found at around 30 sites since 1854. At present, 10 populations are known within a small region of southern Finland: Asikkala (1 site), Padasjoki (4 sites), Hollola (1 site) and Kuhmoinen (4 sites).

6.5.3 Biology

A. pilosa is a 50–150 cm tall perennial herb with a horizontally growing rhizome. Its leaves are yellowish green, turning bright red in autumn. Its flowers have 2.5–4 mm long petals forming a long, usually unbranched, elongated inflorescence or raceme. The hypanthium is deeply concave, becoming hard in fruit, and has hooked bristles. The fruit contains one or two achenes.

The overwintering basal leaf rosettes can be seen already in early spring. Flowering begins in July, but in shaded sites can be delayed until August. There are typically 20–70 flowers in one raceme, but the most luxurious plants on open and sunny sites can have hundreds of flowers on their highly branched inflorescences (Kemppainen et al. 1991). The species needs moderate light for flowering, but excessive sunshine and drought may cause drying of buds. There is no nectar in the flowers (Lagerberg 1957), so they only attract a few pollinators (*Bombus*- and *Diptera* -species). Self-pollination is common. Fruits ripen in August-September and seed production is usually good. The number of vital hypanthia per fertile shoot is usually 30–40 in the Finnish populations (Kemppainen et al. 1991). Fruit production is highest (approx. 300–600 fruits per plant) in open sites, and in populations consisting of large or old plants with plenty of generative shoots. Fruits are dispersed effectively by animals and man, because their hooked bristles easily stick to fur or clothing.

Most shoots bend downwards after flowering, and fruits mostly remain near the parent plant. Germination of fresh fruits varies greatly, but can be accelerated in cold conditions (Roberts 1986). However, seedlings are rarely visible on growth sites, mainly because of dense undergrowth and the lack of open soil in abandoned pastures. Additionally, many achenes are eaten by herbivores, and a large proportion of the seedlings that emerge between the following May and September die during their first growing season. There is no permanent seed bank (Donelan & Thompson 1980).

The ages of individuals are not known, but the oldest plants may be several decades old, with diameters of 30–40 cm and 30–40 generative shoots. In shaded habitats propagation by rhizome is effective, and shoots at distances of several decimetres can originate from the same individual. Plants can produce tens of small (< 15 cm) vegetative shoots, which may remain small for years. It is rather difficult to distinguish these shoots from seedlings without digging them up. The significance of the small vegetative shoots is not clear, but it is possible that they "wait" for a chance to grow.

In the Finnish populations, larvae of *Hypera* sp. (Coleoptera, Curculionidae) were found to eat seeds and green parts of the plants; while moth larvae of one species (*Pyrrhia umbra*, Lepidoptera, Noctuidae) were observed eating their hypanthia.

In both Estonia and Finland *A. pilosa* grows in fairly dry grasslands, in open, rather dry forest margins, on unused forest lanes, and along roadsides. In Finland, part of one population has spread into mixed forest on esker slopes. The soils of the Finnish sites are mainly sandy mull or sand moraine. Many of the present locations are slightly overgrown former pastures and meadows. In Estonia, *Agrimonia pilosa* often grows together with *A. eupatoria* – and hybrids between the two taxa are known – although in Finland the two species only occur together in one location. The habitats of *A. pilosa* are usually more shaded or semi-open sites. Trampling does not disturb the species, and in Estonia it seems to expand successfully along recently created skiing trails. In Estonia, populations are spread and maintained by wild boars: seedlings can survive on old overgrown tracks where the surface is kept open by wild boars. In such areas populations can be large and evidently vital.

6.5.4 Monitoring methods

In Finland, thorough field studies were carried out over the period 1987–1989 on seven populations (Uotila et al. 1990, Kemppainen et al. 1991, 1993), and some of the resultant data has been used in the current monitoring programme. During the research period, several parameters were recorded for populations, individuals and growth sites. Some individuals were also marked for demographic monitoring. Since 1990, only the numbers of generative and vegetative shoots have been counted, but special attention was also paid to searching for seedlings. The boundaries of the sites have also been defined, and changes in habitats have been described.

In Estonia, two populations were monitored during the period 1999–2001 in the counties of Võru and Tartu. The Võru site is near a path running along the edge of a dry boreal forest and a field, while the Tartu site lies on a slope near a road in a dry boreo-nemoral forest. Both sites are partly or completely shaded, with slight human impact.

6.5.5 Results

Finland

In Finland, there are a total of 10 *Agrimonia pilosa* populations, consisting of 27 separate sub-populations. A total of 3,700 shoots were recorded in 2002, of which 50% were generative. Most populations had 100–200 shoots, while the three largest populations consisted of between 700 and 1,400 shoots. Separate sub-populations varied in extent from one to ten square meters, while the largest populations were spread over areas of 500–1,000 square meters. Most of the small isolated sub-populations consist of only one individual, but other sub-populations may contain as many as 200 individuals.

Of the ten populations in Finland, only the three largest can be said to be vital and increasing. In increasing populations new, sexually reproduced individuals are regularly found, and older individuals grow in size vegetatively. Four populations seem to be stable, even though variations were observed in the numbers of small vegetative shoots in particular, but also of and large vegetative shoots and generative shoots. Three populations are clearly decreasing, with the numbers of shoots in all stage classes declining, old individuals shrinking in size, and no new individuals observed.

The histories of these populations vary considerably, including very recent events. Active human impacts, both positive and negative, have been noted at all the monitored sites. Many of the populations have been the target of different management activities, and some populations have been affected by other factors such as changing forestry practices. Various trends in populations can be discerned from the monitoring results of single populations, but generalisations are difficult to make. Moreover, in many cases these positive and negative changes have affected the plants simultaneously, which makes interpreting the monitoring results even more complicated.

The sub-population Jalli-D is an example of a population where changes in the environment due to forestry practices and later management are clearly reflected in the population trend (Fig. 1). In the 1980s, small groups of generative shoots were found on an abandoned pasture which had been planted with birch. During the first years of monitoring (1987-1990), the population suffered both from the shade produced by the growing trees, and from competition with other plants, especially grasses and nitrogen-favouring plants like *Urtica dioica*. The birch plantation was thinned in the beginning of the 1990s, and habitat management began at the same time, with vegetation subsequently mown almost every year. Already by 1992, the total number of shoots had tripled, probably due to increased light. At the moment, the young birch trees have grown to a height of 15 metres, giving partial shade to *Agrimonia* plants. Some new groups of individuals have been found since the beginning of the 1990s, and more than 100 small vegetative shoots, most of which were obviously real seedlings, were found in 2002.

The Asikkala site contains an example of a fairly stable population (Fig. 2). Habitat was managed here every year from 1990 to 1998, involving mowing and manually removing competing plants. This has kept the site fairly open, even though the habitat is unfavourably cool and shaded by a crag. An exceptionally large number of seedlings were found in bare soil patches in 1993. In 1992 and 1995, monitoring was carried out too early, in the beginning of July, and no flowering shoots were observed. In 2000, only the flowering shoots were roughly counted. The extent of the population and the numbers of flowering and vegetative shoots have remained quite stable, even though the site has again become more shady as the surrounding broad-leaved trees have grown.

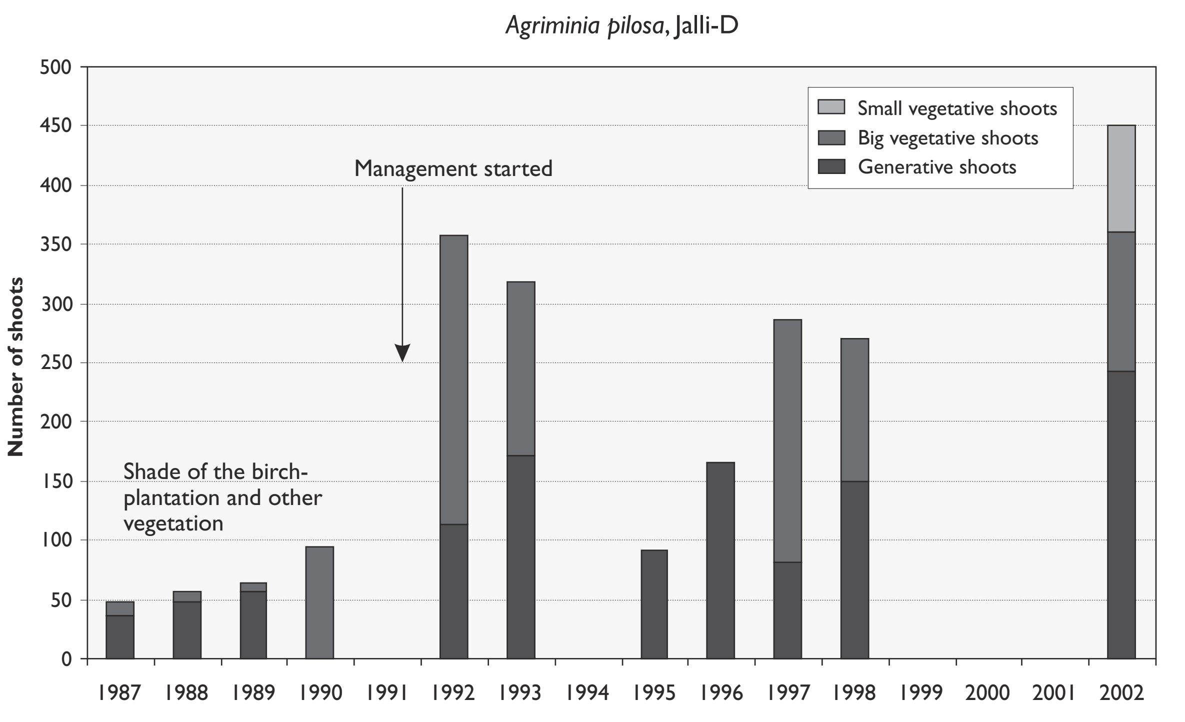

Figure 1. Sub-population of Agrimonia pilosa*, Padasjoki, Jalli-D (Finland). Management by mowing started in 1991. The number of juveniles/seedlings was recorded only in 2002.*

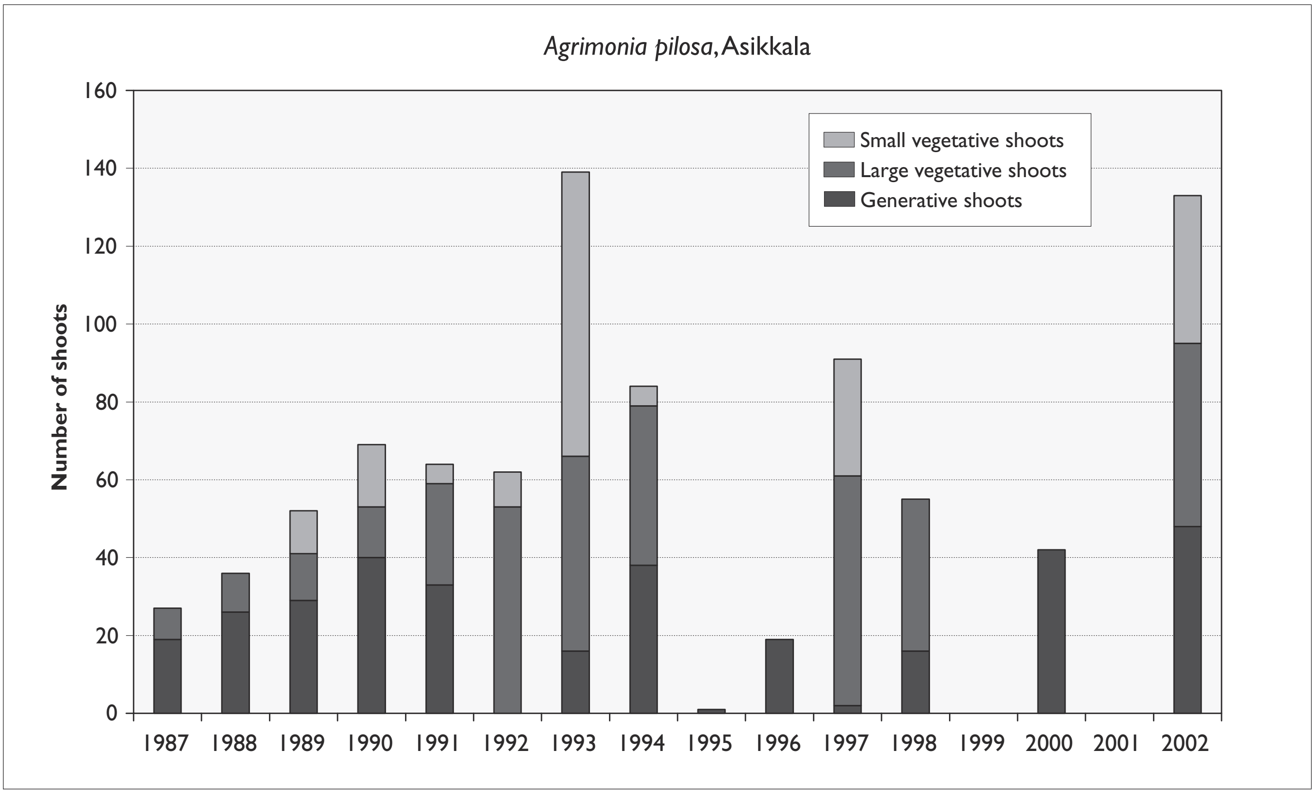

Figure 2. Population of Agrimonia pilosa, *Asikkala (Finland). Habitat management involving mowing and weeding started in 1990.*

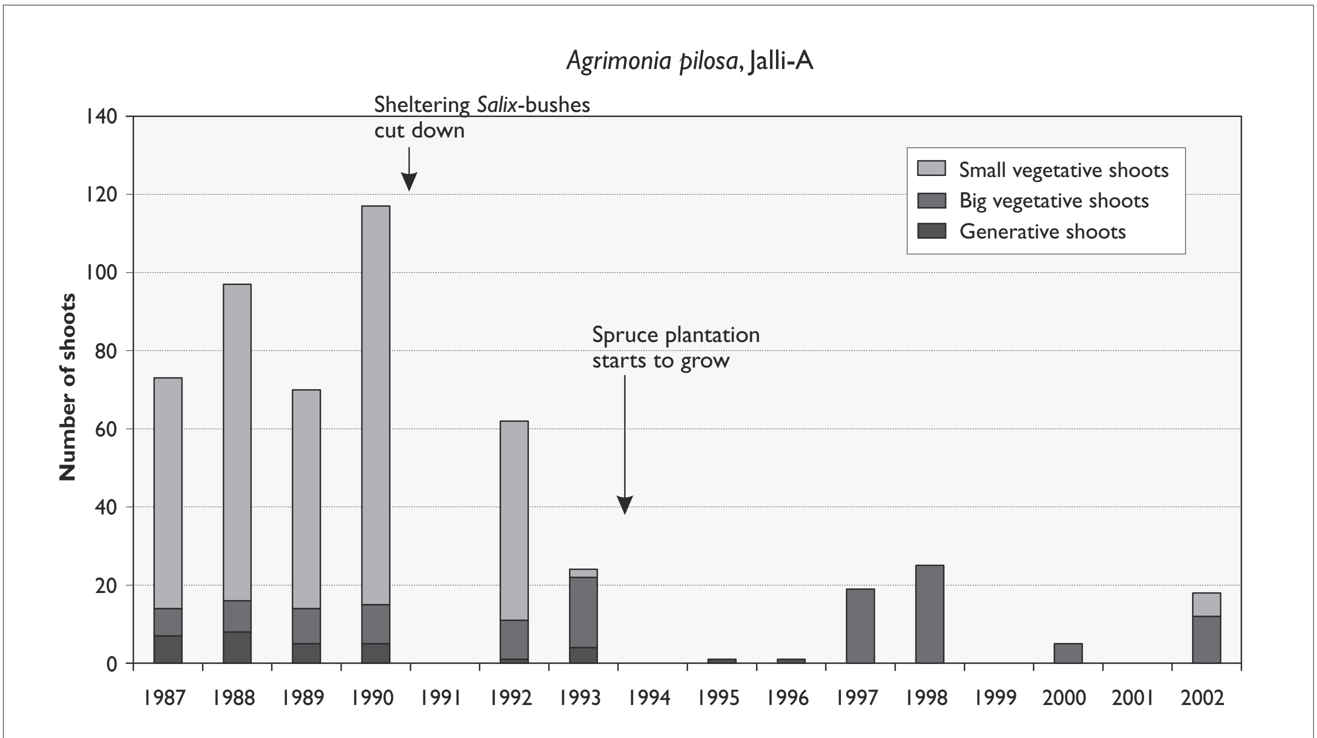

Figure 3. An example of a decreasing sub-population of Agrimonia pilosa, *Padasjoki, Jalli-A (Finland). Many small vegetative shoots were recorded growing under* Salix *bushes in the period 1987–1990. These sheltering bushes were cut down in 1990, which probably exposed the small shoots to too much sunlight. Additionally, a spruce plantation was established on the site in the early 1990s.*

The sub-population at the Jalli-A site is representative of declining populations (Fig. 3). This population, situated at the edge of mixed forest, was examined for the first time in the late 1980s. Few tall flowering and vegetative shoots were observed, but many small vegetative shoots were noted growing under thick bushes of *Salix*. These shoots remained very small (5–15 cm) during the whole four-year research period. The bushes were cut down in the early 1990s and the small shoots disappeared; possibly drying out in the open moraine ground. The adjoining forest was harvested and planted with spruce. The habitat is now becoming too shady for the species. Only a few scattered, mostly vegetative shoots have been observed during the last ten years.

Estonia

In Estonia, *Agrimonia pilosa* has not been widely monitored before. More attention will have to be paid to this plant in future, when Estonia joins the European Union. The locality in Võru county where the monitoring site has been established was only discovered in 1999. The population consisted then of 21 generative shoots, probably originating from a single rhizome. In 2001, on an unused forest lane about 20 m away leading to unmanaged grassland about 100 shoots (mostly generative) were counted. Meanwhile, about 20 shoots were also recorded in 2001 still growing in the original monitoring site from 1999. The monitoring plot is semi-shaded, on dry sandy soil, and at the moment not endangered by human activities. The plants growing on the track will grow vigorously until it either becomes overgrown with bushes, or is used again by tractors.

In Tartu county, a monitoring site on a hill in a sparse pine forest was examined in 2001. The population extended over an area of 32 m², and consisted of 29 shoots. Eighteen of these shoots were generative, 10 vegetative and one juvenile. Later in 2001, a further 100 generative shoots were found in the vicinity of the monitoring site on the slope of the hill in and alongside alder scrub among dense growths of *Pteridium* plants.

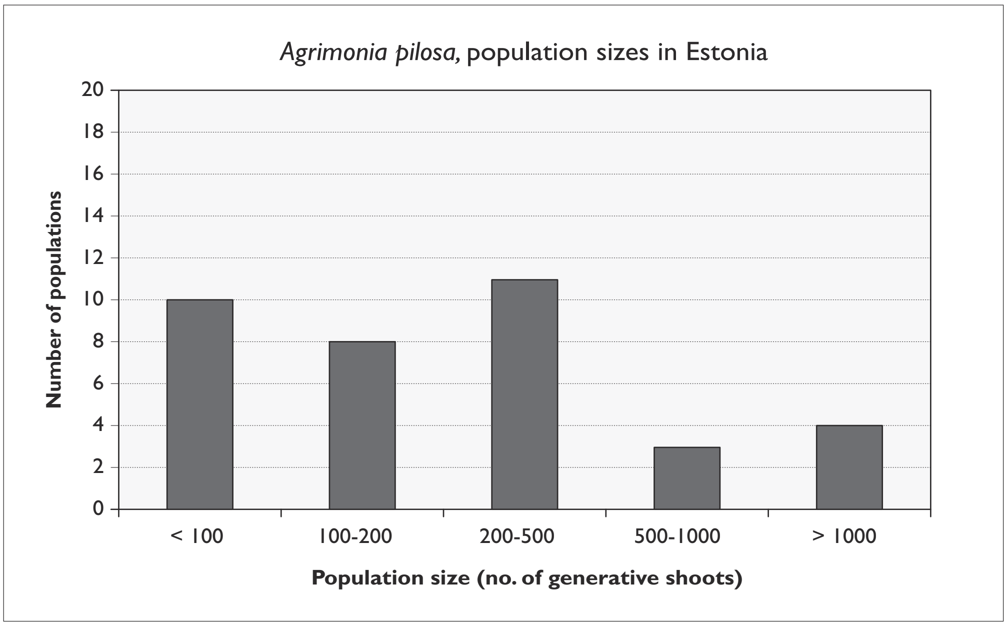

Figure 4. Size distribution of 37 populations of Agrimonia pilosa *in Estonia.*

In 2001 an inventory of *Agrimonia* was carried out for the preparation of Natura 2000 network. This involved surveying 23 sites, and *A. pilosa* was found in 13 of these sites. This does not necessarily mean that *A. pilosa* has vanished from the other sites, since some of the localities were so vaguely described that it was impossible to find them again. Populations had actually disappeared from some sites, however, because of the construction of a new road. In 2002, twenty-four more populations were surveyed in SE Estonia. Most of these sites lie within the Karula Nature Reserve, in a sparsely inhabited region on disused or seldom used forest tracks in mixed spruce/pine forest. Only four sites were on previously cultivated grasslands. Most of the 24 populations surveyed in 2002 contained just over 200 shoots (overwhelmingly generative). The most prolific occurrence is at Kütiorg (Võru county) where about 2,600 shoots were counted, mostly beside a small road in mixed forest. The size distribution of the 37 populations found in 2001–2002 is presented in Fig. 4. In these inventories only the numbers of generative shoots were recorded.

6.5.6 Conclusions

At the beginning of the monitoring of *Agrimonia pilosa*, the question which caused most problems was how to define an individual plant. In some cases, rhizomes formed easily distinguishable patches consisting of tall generative and vegetative shoots. But very often, populations consist of fairly scattered groups of shoots with varying densities, and it is almost impossible to say where one individual ends and the next one begins. Also, the significance of small vegetative shoots near the parent plants is still open. Do large numbers of such shoots indicate vitality or decline? Moreover, distinguishing seedlings and juvenile plants from these small vegetative shoots seems to be very difficult, or even impossible, without looking underground at the rhizome and rooting system.

In future monitoring of *Agrimonia pilosa,* counting the numbers of shoots in each of three classes – generative, large vegetative (> 15 cm) and small vegetative (< 15 cm) – would evidently be an efficient and sufficiently accurate way to monitor population trends. In future, special attention should be paid to the existence of small vegetative shoots, and to distinguishing them from real seedlings and juveniles.

Monitoring has so far focused on previously known groups of plants, and has not been fixed to a particular area. It might be useful to establish experimental permanent plots on monitoring sites, as careful examination of survey squares previously thought not to contain *Agrimonia pilosa* might lead to the discovery of more true seedlings and single-shooted juvenile plants. On the other hand, for plants like *Agrimonia pilosa* which are strongly dependent on certain human activities, it could be more effective to concentrate on carrying out the right types of habitat management rather than more detailed monitoring.

The habitats of *Agrimonia pilosa* are in both countries strongly influenced by man: sites exhibit changes due to natural succession, forestation, logging and also habitat management activities. It is therefore very important to record the dates (years) and nature of any events or human activities that might affect growth conditions.

The timing of monitoring may lead to difficulties in interpreting the results of monitoring. Early July is usually too early for monitoring, because generative shoots are not yet visible. Sites have usually been monitored in late July – early August, which is the best flowering time. After flowering, the shoots droop, which makes them difficult to find and count. Towards the end of the flowering season it is also possible to estimate seed production, since the fruits are by then already ripening in the lower parts of the inflorescence.

A detailed monitoring programme for *Agrimonia pilosa* in Finland is under preparation, as the species is listed in the EU Habitats Directive.

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6.6 Cypripedium calceolus *L. – Interpretating population trends through short-term and long-term monitoring*

English: Lady's slipper orchid
Estonian: Kaunis kuldking
Finnish: Tikankontti

Tiiu Kull

6.6.1 Introduction

Cypripedium calceolus is one of the flagship species of nature conservation, and is legally protected throughout Europe and Russia. The species is also protected at the supranational level by the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention), the EU Habitats Directive, and the CITES Convention on International Trade in Endangered Species. *Cypripedium calceolus* is classified in Estonia as care demanding (Category 4, Lilleleht 1998), and in Finland as vulnerable (VU; Rassi et al. 2001).

6.6.2 Biology

Cypripedium calceolus is a long-lived clonal species with annual ramets. Many clones are more than 30 years old, and the life-spans of some have been estimated at over 100 years (Kull 1988). The vegetative stage of a young plant before flowering lasts at least 6–10 years (Fast 1985; Rasmussen 1995). An aerial leaf with a very long sheath typically emerges in the fourth spring after seed germination (Fuchs & Ziegenspeck 1926; Curtis 1943). Over the following years the elongating and enlarging rhizome produces ramets with increasingly larger leaves annually. The creeping horizontal rhizome, with a diameter of 0.4–0.9 cm, is situated at a depth of about 10 cm. Rhizomes generally produce two apical buds every year. From the larger bud the following year's shoot develops, forming the new increment (average length one centimetre) of the sympodial rhizome. The position of the larger bud (left or right) alternates each year, resulting in the characteristic zigzag growth pattern of the rhizome (Kull & Kull 1991). In northerly climes these developments can be slower, and it may take more than a year for a bud to form a new shoot above ground (Blinowa 1998). When the rhizome has grown large enough, the smaller bud also produces a ramet, and the rhizome thus forms branches. Adult clones have ramets with 3 to 6 leaves. Juveniles have one or two small leaves and a thin stalk.

Yellow and brown trap-flowers (1 or 2 per shoot) of *C. calceolus* lack nectar, and pollinators are deceived as no reward is available. Medium-sized female solitary bees of the genera *Andrena, Lasioglossum* and *Halictus* are the most frequent pollinators, at least in Sweden (Nilsson 1979).

The fruit-set throughout the range fluctuates from a few per cent to about 20–50%. The number of seeds in each capsule varies between 5,940 and 16,700 (Kull 1999). The fruit-set is pollinator-limited. The plants' dust-like seeds are wind-dispersed.

Flower-producing shoots may appear earlier than vegetative shoots in spring. Flowering begins in May or June, and in northern sites even in July (Eberle 1973;

Vorobjeva & Moskvitcheva 1987). Flowering lasts for 2–3 weeks. Flowers may persist for 11–17 days, but they typically wither on the sixth day after the pollen has reached the stigma (Savina 1964). Shoots start to turn yellow in August. Fruits ripen in September. Capsules split open and liberate seeds in September-October.

A new rhizome segment starts to grow at the end of flowering. Above-ground parts of juveniles persist for considerably shorter periods than adult ramets, appearing shortly before the adult ramets flower, and withering before the other plants in August.

6.6.3 Ecological demands

Cypripedium calceolus is favoured by soils which are moderately moist, and nutrient-poor to moderately nutrient-rich, particularly nitrogen-poor, base-rich, neutral to moderately acid soils. *C. calceolus* grows in a variety of habitats, including both deciduous and coniferous woodland, open scrub, and wooded meadows. In northern conditions, the species occurs in herb-rich forests and rich fens with spruce and pine. *C. calceolus* is sensitive to the presence of a dense bush layer, and increasing shade is a limiting factor.

6.6.4 Distribution and population size

About 200 localities of *C. calceolus* have been documented in Estonia. Most populations consist of less than 100 shoots, although some localities contain thousands of specimens. The biggest populations in Estonia lie in the western islands and in the northern central part of the mainland, although isolated occurrences are scattered all over the country. In Finland, *C. calceolus* has been recorded in approximately 400 localities. The largest populations are in northern Finland and in the Åland islands. *C. calceolus* is rare in the southern part of mainland Finland, where there are only a few isolated populations (Ilmonen & al. 2001).

6.6.5 Monitoring methods

In Estonia, monitoring of *C. calceolus* was started in five sites in 1985 (one population in Ussisoo had already been monitored since 1978). The permanent plot method was used in these sites, but the size of the plot varied depending on the density of the population. In 1994, the state monitoring programme started, and 10 m x 10 m plots were set up at five sites, with all specimens mapped on every plot. Annual records have been kept of the heights of ramets, and the numbers of leaves, flowers and fruits. The light conditions at each site were measured using the fish-eye photography method, enabling the calculation of the light penetration coefficient (or diffuse site factor) (Anderson 1964, Madgwick & Brumfield 1969). This coefficient (consisting of values from 1 to 0) describes the amount of light reaching the herb layer as a proportion of the light that would be available on a completely open site. Habitat types were identified, and the abundance of other herb species on the plots was also recorded. The types and degrees of human impact and other damage were additionally recorded. The methods applied involve the monitoring of orchids over 3 consecutive years, with the next 3-year-period starting in the fifth year after the previous monitoring round ends.

6.6.6 Results

In Estonia, monitoring has focused on seven *C. calceolus* populations in different parts of the country with different habitat conditions (Table 1).

Table 1. Monitored populations in Estonia.

Site	Population size (no. of flowers)	Plot size, m^2	Mean number of ramets on plot ± st. dev.	Mean number of juveniles on plot ± st. dev.	Habitat	Soil pH	Cover of herb layer	Light penetration coefficient
Ussisoo	200	100	179±19	3±2	boreo-nemoral spruce forest	6.8	0.8	0.21
Tooma	100	400	89±11	2±2	drained marshy forest	5.5	0.7	0.15*
Muhu I	40	100	67±11	5±3	wooded meadow	6.9	0.7	0.18
Muhu II	2,000	100	211±18	12±6	alvar forest	7.2	0.8	0.24
Õisu I	130	100	394±90	124±64	drained marshy forest	6.3	0.5	0.30
Hiiumaa	800	2	218±23	85±43	coastal alvar forest	7.5	0.5	0.46
Puhtu	15	100	34±4	1±1	nemoral forest	7.2	0.6	0.13*

The numbers of ramets have fluctuated in all the monitored populations. Figs. 1-3 show the dynamics of ramet numbers in the Ussisoo population. Fig. 1 presents data obtained since 1978 (excluding 1980 and 1981 when there was no monitoring) showing a clear increasing trend. However, if only the data obtained since the beginning of the state monitoring programme in 1994 is considered, the population shows no growth (Fig. 2). Fig. 3 contains monitoring data from two 3-year-periods, representing data sets similar to those that will be produced by applying the proposed monitoring methodology.

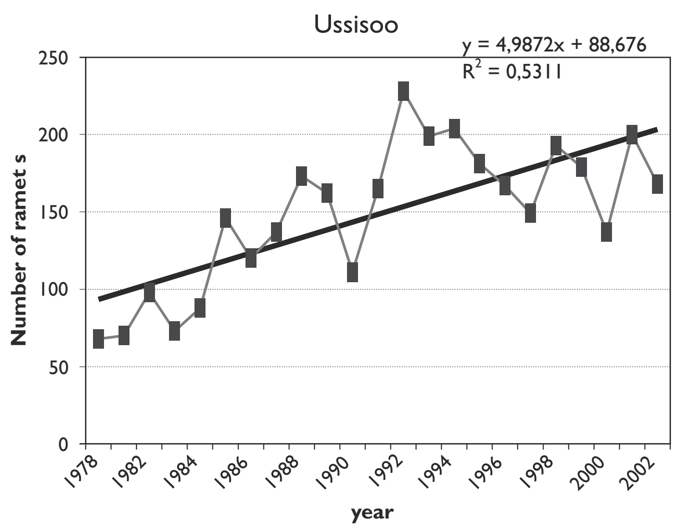

Figure 1. Dynamics of ramet numbers on a permanent plot in Ussisoo, 1978–2002.

6.6.7 Recommendations for management and monitoring

The permanent plot method is important to apply in order to understand how plants behave in a wild population. It takes a long time to reveal the changes in such a long-lived species as *Cypripedium calceolus*. Natural fluctuations are fairly large. Our long-term data shows that longer-term trends in the dynamics of populations are not visible over just a few years of monitoring. We cannot say that a population is decreasing or increasing if the data set is shorter than 5 consecutive years. Even monitoring periods of 9 years may show no clear trends, due to the effect of such fluctuations (Fig. 2).

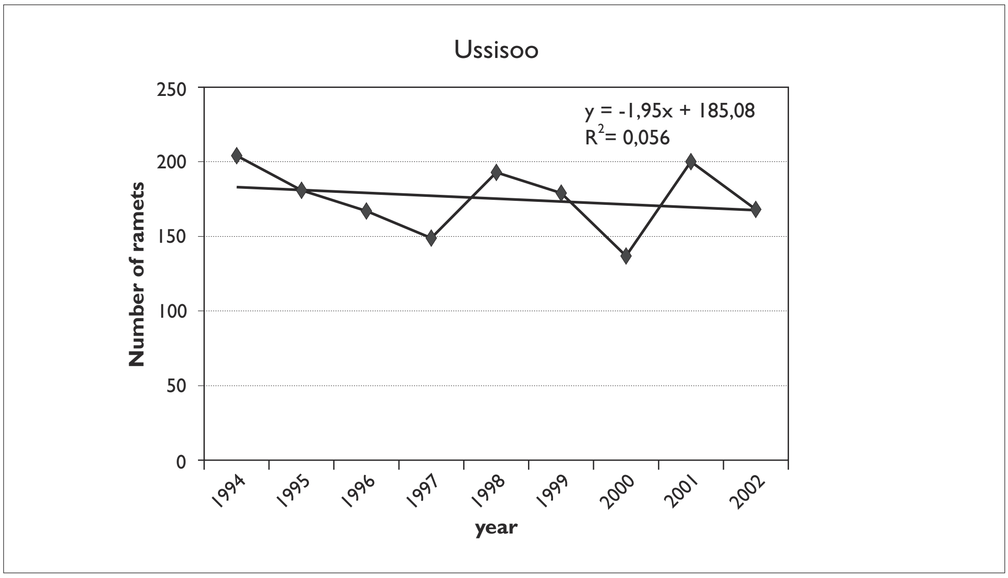

Figure 2. Dynamics of ramet numbers on a permanent plot in Ussisoo, 1994–2002.

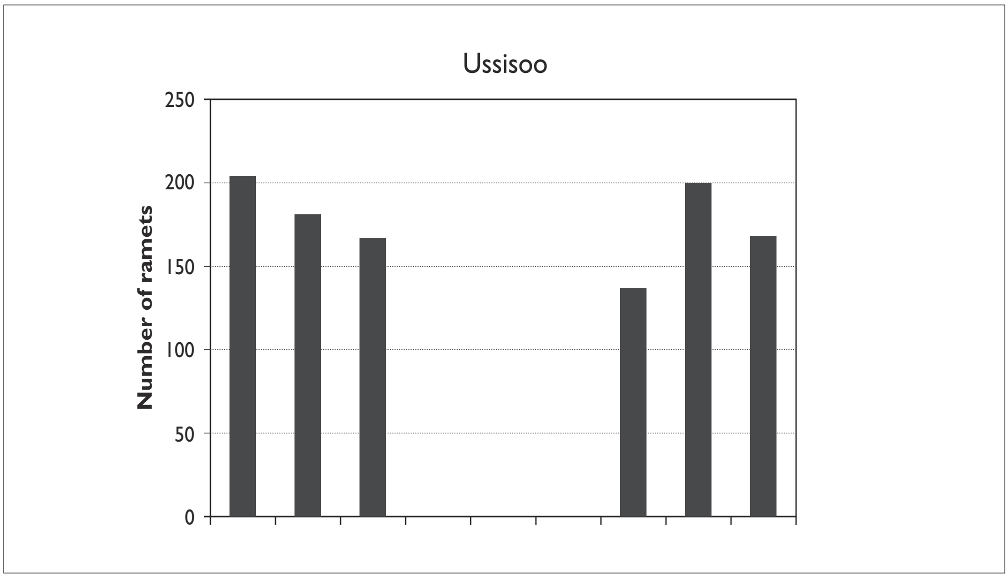

Figure 3. Dynamics of ramet numbers on a permanent plot in Ussisoo, 1994–1996 and 2000-2002.

As has been reported for many other species, a large percentage of juveniles is a good indicator of a vital, growing population. Vegetative reproduction is significant in the majority of *C. calceolus* populations, and if the number of genets is not too low, populations with few juveniles may also grow and persist, as long as the habitat conditions are suitable. However, clone size may decrease as habitat becomes overgrown by shrubs.

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6.7 Cypripedium calceolus *L.* *– How can the monitoring requirements of the Habitats Directive be met?*

Anne Jäkäläniemi & Terhi Ryttäri

6.7.1 Introduction

Cypripedium calceolus is classified as vulnerable (VU) in Finland (Rassi et al. 2001), since the number of populations has declined, largely due to changing farming and forestry practices and the widespread drainage of mires. Since *Cypripedium calceolus* is also a species of European Community interest, any changes in its conservation status have to be reported to the European Commission every sixth year. The first assessment of the species' conservation status was made in connection with the scientific evaluation of the Finnish Natura 2000 network proposals (Ilmonen et al. 2001). This was a laborious process, as very many sites were involved, but the information available on these sites was often inaccurate and uncertain. Based on this assessment, however, it was estimated that *Cypripedium* currently occurs in around 400 localities, about half of which were situated within the Natura 2000 network. In parts of Finland as many as 80% of the species' occurrences lie inside Natura 2000 areas. The conservation status of the species was rated as partly favourable, meaning that while many growth sites are protected, even inside these protected areas habitats may have lost their natural conditions because of human impact, and many populations may be unable to regenerate.

A key question arises in the case of *Cypripedium*: how can Finland meet the monitoring obligations of the EU directive satisfactorily, when there are several hundred populations of a species, when the status and exact location of all sites are not known, and when the resources available are limited? This case study will examine how this issue could be resolved.

6.7.2 LIFE-project: Conservation of Cypripedium calceolus *and* Saxifraga hirculus *in Northern Finland*

Before designing a suitable monitoring programme for *Cypripedium*, it is vital to improve the insufficient site location data. More information is also needed on the management needs and the viability of populations. This requires extensive surveying work. In Northern Finland, data is being improved through a special project, financed by the EU's LIFE-Nature Fund.

The central aims of this project are to determine and improve the conservation status of the two target species, and to collect enough data to get a clearer view of the species' biology, dynamics, habitat demands and management needs. The project area is situated in Northern Finland, where the most of the growth sites of the two species are found. During the related inventories the number of *Cypripedium* populations was found to be much higher than had previously been thought: 437 populations were found within Natura 2000 sites alone, and all of these occurrences will be mapped. Unfortunately, only a few of the sites outside the Natura areas can be studied. But at each site surveyed, data on population size and structure, habitat structure and quality, and management needs will be collected. On the basis of this data, the general conservation status of the species will be more accurately assessed. Additionally, ten *Cypripedium* growth sites inside Natura sites and another ten sites outside the network will be managed by removing trees, and the effects of this management will be monitored by assessing demographic data. For long-term monitoring, a further fifteen reference areas will be established inside Natura sites. Furthermore, habitat restoration work will be done at five ditched sites. The possible existence of seed bank will also be studied from soil samples, and some sites where the species has become extinct will be recolonised through transplantations.

6.7.3 Monitoring programme

What kind of information is needed?

Favourable conservation status consists of the following components
(see also p. 11):

a. population dynamics data on the species indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, and
b. the natural range of the species is not likely to be reduced in the foreseeable future, and
c. there is now, and will continue to be, a sufficiently large habitat to maintain its populations on a long-term basis.

Thus the questions to be answered during the monitoring are:

1. are a sufficiently large proportion of populations *viable and able to reproduce*?
2. are there *enough habitats* available for the species to continue to thrive?
3. is the *natural range* of the species shrinking?
4. is the *number of sites* decreasing?
5. are *habitats* declining in quality?
6. is the *relationship between natural and disturbed sites* changing?

Monitoring should provide general answers for these questions for reports to be made once during each six-year monitoring period. It is important to have reliable and sufficient data on the species' populations before schedules can be set and populations selected for a monitoring programme.

Monitoring proposal

General monitoring is needed in order to obtain data on the natural range of the species (question 3), the number of sites (4) and the relationship between natural and disturbed sites (6). To examine variations in the natural range of the species, populations should be specially selected for study from the edges of its range. To study the trends in the number of sites, a sample of populations should be selected from the species' entire range – from each province. In provinces with very few sites, all populations could be monitored once every six years. However, in provinces where there are many sites, only a representative sample (e.g. 30%) of sites can feasibly be examined during each six-year monitoring period. Populations situated on the edges of the species' range should be also be included in this way in the monitoring schedule once during every six-year period. The site sample should additionally include populations living in natural conditions, and populations affected by human activities; as well as populations both inside and outside protected areas. One very suitable tool for collecting this kind of data is the data collection sheet used to collect information on populations for the database of Finnish threatened species (see p. 27).

To get reliable data on fluctuations in population sizes, the viability of populations and their ability for reproduce (question 1), permanent *plot monitoring* will be necessary for some populations. This would involve, for instance, carrying out monitoring every three years, counting the numbers of flowering plants, vegetative plants, young ramets and seedlings in ten squares of one square metre along a transect, in order to get a good indication of the structure and reproductive ability of a population. In order to analyse the quality of the habitats and the viability of the monitored populations, certain environmental parameters should also be included in the monitoring regime (5). These can include coverage estimates for canopy, scrub below and above 2 metres at the beginning, centre and end of the transect; and the coverage of species in the bottom and field layers at 5-10 randomly chosen 1 m^2 survey squares. These questions can only be answered by examining a representative sample of different kinds of populations taken from the whole distribution area of a species.

Data on the amount and quality of suitable habitat for the species can initially be collected at the sites where the species actually grows, but more information should become available later, in the form of data obtained during the monitoring of habitat types listed in the Habitats Directive (2).

The monitoring programme planned for *Cypripedium* has not yet started, although new data on the growth sites and biology of the species is being collected as part of the LIFE-project described above. Data on the species' growth sites will be stored in the threatened species database maintained by the Finnish environmental administration. Responsibility for analysing this data is shared between the Finnish Environment Institute (southern populations) and Metsähallitus (northern populations). The overall conservation status of *Cypripedium calceolus* will be evaluated jointly by these two organisations.

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6.8 *Epipactis palustris* (L.) Crantz

English: Marsh helleborine
Estonian: Soo-neiuvaip
Finnish: Suoneidonvaippa

Terhi Ryttäri & Kimmo Syrjänen

6.8.1 Introduction

Epipactis palustris is an attractive orchid found in lime-rich fens and wetlands. In Finland, the species is classified as vulnerable (VU; Rassi et al. 2001). It has disappeared from several of the localities where it formerly occurred, due to the drainage of rich fens and the earlier conversion of rich fens into fields. In Estonia, *E. palustris* is protected in Category III (see page 14). Overgrowth is a threat to the species, especially in small rich fens and riparian habitats. Many populations are found on ditched mires, which increases the risk of disappearance.

6.8.2 Biology and ecology

Epipactis palustris is a long-lived perennial orchid. It has a long and thin rhizome which grows horizontally a couple of centimetres below ground. Thanks to their efficient vegetative growth, individuals may inhabit quite large patches of ground (Summerhayes 1951). The flowering stems may exceed 40–50 cm in height and bear even tens of flowers. The leaves are lanceolate in shape, and have three to five prominent veins. The bases of the leaves and stems often bear violet sheaths. (Lang 1980)

In Estonia, *E. palustris* starts flowering after midsummer. In Finland, flowering begins in late July and lasts for two or three weeks until mid August. In northern populations, the flowers are often exposed to frost, and one cold night during the flowering period can destroy all the flowers and seed production. *E. palustris* is mainly cross-pollinated (Brantjes 1981, Vuorinen 1991), but the plant is self-compatible and automatic self-pollination is possible, although the relative importance of cross and self-pollination varies greatly (Proctor et al. 1996). Many insect species are known pollinators. In Southern Sweden, in Skåne and the island of Öland, the most typical pollinator is the wasp *Eumenes pedunculatus* (Nilsson 1978). Observations in Southern Finland revealed that the most frequent visitors to *E. palustris* flowers were syrphid flies (Syrphidae) (Vuorinen 1991). Syrphids were also the most efficient pollinators, especially *Metasyrphus latifasciatus*, which carried as much as 43% of all the pollinia observed in different species. Fertilisation and seed production are thought to be quite effective. According to Summerhayes (1951), an average of 80 percent of the flowers produce ripe fruits. Our observations suggested that the capsule production of *E. palustris* is significantly lower, varying from total failure to about 40% success rates in the best years. The growth of local populations seems to be based on vegetative reproduction and branching of the rhizome, while seed production contributes primarily to the colonisation of new sites. The plants' seeds maintain their capacity for germination only for a very short time (Linden 1980).

E. palustris favours moist habitats rich in lime. In both Estonia and Finland the species' habitats are mostly rich fens, although plants also grow on moist lime-rich riparian meadows. In rich fens, plants grow on fairly open intermediate levels (where the water table is 5–20 cm below ground) and avoid the wettest parts of fens – flarks (where the water table is less than 5 cm below ground). Ideal growth sites for this species are rich virgin fens with a few flarks, but enough open space and some shade under bushes (Vuorinen 1991). The plants' shoots are sensitive to drought and trampling. *E. palustris* has probably benefited from the earlier mowing and grazing of rich fens.

6.8.3 Distribution

The range of *Epipactis palustris* is extensive, covering almost the whole of Europe. The species grows throughout Estonia, but is most frequent in the lime-rich western parts of the country, where it may still occur in hundreds of sites (Kull & Tuulik 2002). In Finland, *E. palustris* is rare, mainly due to the lack of suitable lime-rich growth sites. More than 60 occurrences have been recorded in Finland at one time or another (Ranta 1997). Most extant populations are in the Åland Islands, however, and the species' distribution in mainland Finland is very scattered. *E. palustris* has recently managed to invade new sites influenced by man, such as roadsides and old limestone quarries.

6.8.4 Monitoring methods

In Finland, monitoring was carried out on four *E. palustris* populations: two in southern Finland (Hanko and Karkkila), one in central Finland (at Juuka), and one further north (at Tervola) which is the northernmost known population (Table 1.). In Estonia, one population was monitored on the island of Saaremaa. The monitoring period was 1997–1999. At Karkkila, a comparison could be made with earlier monitoring done over the period 1986–1989 (at one of the three plots). Earlier information was also available for the population at Juuka on population size trends.

At each site a monitoring plot of about 10 m x 10 m was designated (Fig. 1.). The size of the plot varied depending on the area, and the extent and boundaries of the population. For the largest populations at Tervola, Hanko and Karkkila, 2-3 sub-plots were set up. The population on Saaremaa was so dense that only a sample of ten 1m x 1m survey squares were investigated. Sampling was systematically organised, diagonally across the monitoring plot. As shoots were counted on plots of varying sizes, the data was converted to produce density figures for areas of 100 m^2. In the first year of monitoring, the location of each shoot was measured by co-ordinates but this was soon found to be too time-consuming and ineffective. Since 1998, only the numbers of vegetative and generative shoots have been counted. To help compare the populations, the lengths of a set of vegetative and generative stems were measured, and surveyors also counted the numbers of leaves and flowers on these stems. The aim was to time the monitoring visit so that it would be possible to record capsule production for each population. Capsule production is presented as a proportion (%) of capsules of all flowers (capsule production = no of capsules / (no of withered flowers + no capsules) x 100).

Table 1. Monitored populations of *Epipactis palustris*. The Saaremaa population is in Estonia, the others are in Finland. All sites are on rich fens.

Population	Latitude	Number of monitoring plots	Total area of the plots (m^2)	Condition of the site
Saaremaa	58°15'	1	100	Natural
Hanko	59°55'	3	75	Natural
Karkkila	60°10'	3	208	Natural
Juuka	63°10'	1	136	Natural
Tervola	66°10'	3	326	Partly natural, partly ditched and restored

The monitoring plot (10 m x 12 m) of *Epipactis palustris* at Karkkila site, Finland.
Inventored 19.8.1999 by Terhi Ryttäri and Kimmo Syrjänen. (No. of veget./gener. shoots)

	A	B	C	D	E	F	G	H	I	J
12	0	0	0	0	0	0	0	0	0	2/0
11	0	0	0	0	0	0	0	2/2	15/0	3/0
10	0	0	0	0	0	2/0	6/0	46/0	42/0	4/0
9	0	0	0	1/0	1/0	0	1/0	16/0	18/0	13/0
8	0	0	8/0	28/0	9/0	0	1/0	3/0	2/0	3/0
7	0	0	16/0	19/0	0	5/0	10/1	0	0	0
6	0	0	6/0	5/0	0	2/0	2/0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
4	0	0	1/0	1/0	0	0	0	0	0	0
3	0	0	12/0	11/0	0	0	0	0	0	0
2	2/1	5/1	12/0	14/0	1/0	0	0	0	0	0
1	1/0	2/2	0/1	2/0	0	0	0	0	0	0

Figure 1. Numbers of vegetative/generative shoots observed in each 1 m^2 survey square at one of the monitoring plots at Karkkila.

6.8.5 Results

Trends in the numbers of shoots per population and the proportions of flowering shoots are shown in Fig. 2 and 3. Three populations (Hanko, Karkkila, Juuka) exhibited no significant trends in the number of shoots. At Saaremaa, and especially at Tervola, there seemed to be an increasing trend in the number of shoots per plot.

At Saaremaa, the southernmost monitored population showed the highest densities, varying from 1,593 to 2,228 shoots / 100 m^2 over the three-year monitoring period. In all three Finnish populations (Hanko, Juuka and Tervola), densities were clearly lower than at Saaremaa, varying between 773 and 1,177 shoots / 100 m². The densities recorded at Karkkila were lowest, varying between 14 and 264 shoots / 100 m²; and plants were also absent from many of the survey squares within the three plots.

The proportions of flowering shoots were fairly low in all the monitored populations (Fig. 3). They were lowest for the Juuka population (less than 1% every year monitoring was conducted). The populations at Saaremaa and Karkkila were rather similar, in that flowering rates varied between 1.6% and 5.1%. In the Hanko population, the proportion of flowering shoots was highest, varying between 18.2% and 26.2%. The most interesting result was obtained by comparing the two increasing populations: at Saaremaa and Tervola. In the Saaremaa population, both vegetative shoots and flowering shoots were increasing, whereas at Tervola, the number of flowering shoots remained stable, while the proportion of flowering shoots diminished.

For the population at Karkkila an earlier data-set was also available from monitoring in 1986–1989 (Vuorinen 1991). The same plot established in 1986 was also examined in the later monitoring period. The number of shoots in the plot does not vary much until after the first monitoring of the second period (Fig. 4). A very different trend can be seen in the population at Juuka (Fig. 5). During the period 1983-1986 "monitoring" merely consisted of walking around and counting individuals (Hakalisto 1987). In 1987, a more formal monitoring plot was established and each survey square within the plot was carefully examined (unpublished report by A. Kurtto, P. Heikkinen and L. Helynranta). As a result there was a sudden increase in the number of shoots observed. For the Juuka population a simple habitat description was made in 1987 (Fig. 6).

Some morphological measurements were also made in the populations (Table 2). Both generative and vegetative stems seem to grow higher in the southernmost population in Saaremaa, but there is considerable variation even within single populations. There were no significant differences in the numbers of leaves per stem. The average number of flowers seems to decline northwards. Unfortunately, the morphological data is not fully comparable, since measurements were taken at quite different dates in different sites.

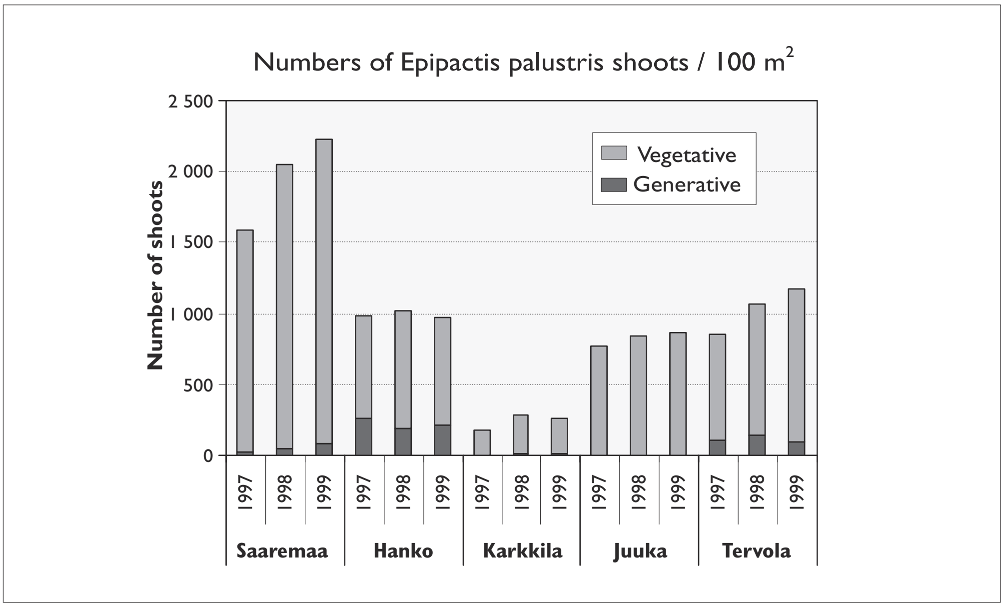

Figure 2. Variations in shoot densities in Epipactis palustris *populations in Estonia and Finland, 1997–1999.*

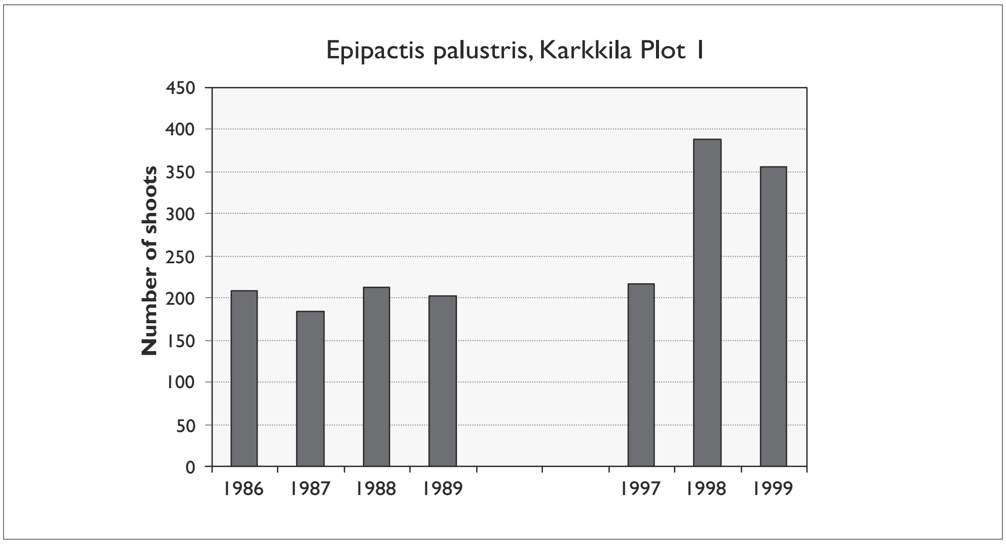

Figure 3. Total number of shoots counted during monitoring of the Epipactis palustris *population at Karkkila, Finland (plot 1), 1986–1999.*

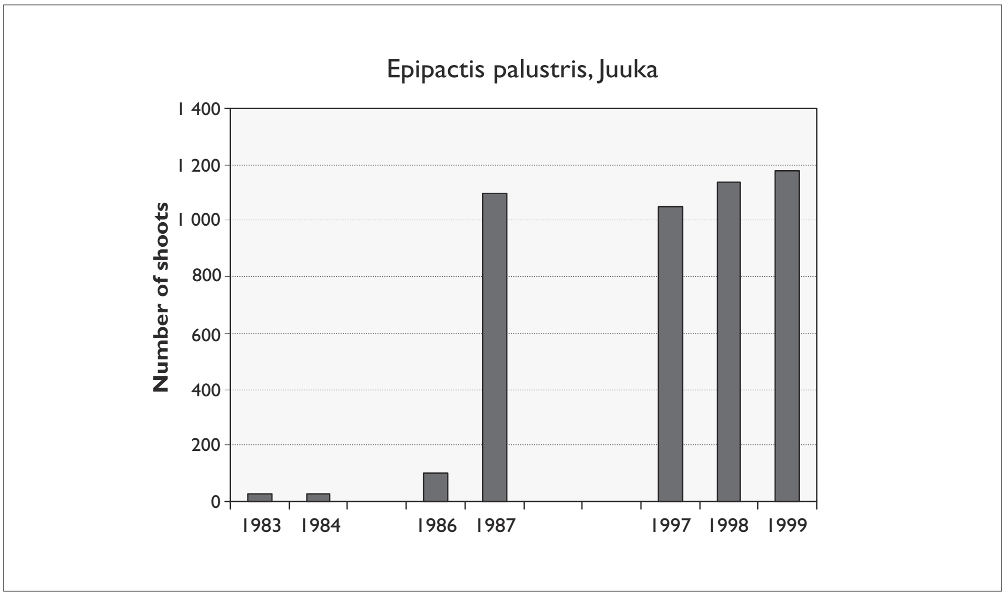

Figure 4. Total number of shoots counted during monitoring of the Epipactis palustris *population at Juuka, Finland, 1983–1999.*

0	3	15	17	6	0	0	0	0	1	1	0	0	14	33	6
10	9	6	5	1	1	1	0	11	37	28	1	3	4	6	13
6	4	3	0	0	16	49	43	36	24	14	0	0	1	19	26
0	10	3	0	1	43	30	6	36	50	17	11	0	0	0	1
0	10	2	0	1	10	11	3	30	17	15	3	0	0	1	1
0	3	10	0	0	2	1	0	32	62	59	11	0	0	6	6
0	0	0	0	0	0	0	2	36	52	50	33	8	0	15	1
0	0	0	0	0	0	0	0	9	29	8	3	2	0	9	1

Figure 5. Numbers of Epipactis palustris *shoots on 1 m^2 survey squares of different vegetation types at the Juuka site. The black squares consisted mainly of flark level vegetation, the light grey squares were at the hummock level, and the dark grey squares were of intermediate vegetation level. Source: Inventory of* Epipactis palustris *in Juuka, Arto Kurtto, Pertti Heikkinen and Leena Helynranta, 1987 (unpublished report).*

Table 2. Morphological measurements of *Epipactis palustris* populations in Estonia and Finland. (* = no data available)

	Saaremaa (30.8.1999)	Hanko (23.7.1997)	Juuka (31.9.1997)	Tervola (21.7.1998)
Generative shoot				
Average length, cm (min, max)	34.6 (21-53)	30.0 (19-43)	28.5 (22-36)	20.3 (3-41)
Average number of leaves (min, max)	5.5 (3-7)	5.1 (5-6)	*	4.3 (3-6)
Average number of flowers (min, max)	6.9 (1-11)	4.7 (1-11)	4.4 (2-6)	3.5 (1-11)
Vegetative shoot				
Average length, cm (min, max)	14.1 (2-39)	9.9 (2-25)	3.9 (1-20)	*
Average number of leaves (min, max)	*	3.9 (2-6)	*	*

Capsule production rates in the populations varied considerably both between populations, and over different years (Fig. 7). In some years capsule production was very low (e.g. 8% in the Hanko population in 1997). During the three-year monitoring period, the highest capsule production rates were around 40% in the three southernmost populations, and between 5% and 28% in the two northernmost populations (Juuka and Tervola). In 1997, capsule production in the Tervola population was evidently very high, but as the number of withered flowers had not been counted, a fully comparable figure could not be calculated.

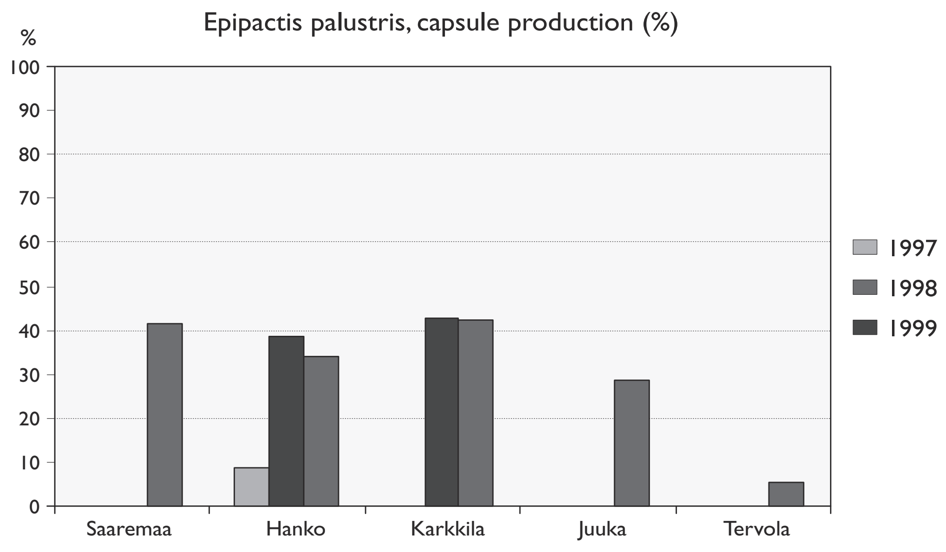

Figure 6. Capsule production (the proportion of capsules of all flowers) in Epipactis palustris *populations in Estonia and Finland.*

6.8.6 Discussion

Although the data-set for this case study of *Epipactis palustris* is limited, a lot can be learnt from this monitoring work, and important new questions have arisen. It was soon noticed that measuring the exact co-ordinates of shoots is too time-consuming – in fact this should have been realised before monitoring began, as the vegetative growth system of the plant is well known. Instead, a much more effective way to monitor trends in populations was to establish plots, and then count the shoots in each square metre. The case of the Juuka population (Fig. 5) particularly shows that after a monitoring plot was established the site was examined much more carefully than before, when only the flowering stems had been well recorded.

Three monitoring sites (Hanko, Karkkila, and Juuka) did not show any clear increasing or decreasing trend. At two sites (Saaremaa and Tervola) populations appeared to be increasing, but it was hard to determine any reason for these trends. One difference noted between the two increasing populations was that in Tervola the proportion of flowering shoots seemed to be diminishing although the total number of shoots was increasing. It would be gratifying to interpret this growth in Tervola as the product of habitat restoration work carried out on this site – clones may have started to produce more young shoots due to an improved water balance. One of the Karkkila plots (Fig. 4) also shows an increase in the number of shoots – one explanation for this sudden increase might be the effect of monitoring itself: trampling on the site may have made the ground more open, and induced the rhizome to accelerate growth. A more probable explanation is that monitoring was done in 1997 so early in the season (30th June) that all vegetative shoots had not appeared yet. Surveyors may also have gradually become more skilled during the monitoring period at observing the smallest vegetative shoots.

To record capsule production, an extra monitoring visit would have been necessary, but this would have led to extra trampling on a sensitive site. A suitable period for monitoring *Epipactis palustris* is from the end of July (in Estonia) or from mid August (for northern populations) until the end of September.

The effects of monitoring itself need to be better assessed. Trampling may increase the area of the wettest flarks, where *Epipactis* is not able to grow. But little is known about the persistence of the effects of trampling. One possibility would be to monitor any changes in the patterns of hummock level, intermediate level and flark level vegetation on a plot. This type of analysis was carried out on the Juuka plot in 1987, with the dominating vegetation level recorded for each square metre (Fig. 6). Making similar survey observations again for the same plot would be a simple and effective way to monitor such changes in the growth site.

Finally, analysis of the monitoring practices used for monitoring *Epipactis palustris* clearly showed the importance of giving surveyors precise instructions about all the procedures to be followed at monitoring sites. The collection of data on capsule production was partly unsuccessful because of poor instructions, for instance.

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6.9 Epipactis atrorubens *(Hoffm, ex Bernh.)* Besser

English: Dark-red helleborine
Estonian: Tumepunane neiuvaip
Finnish: Tummaneidonvaippa

Anne Jäkäläniemi

6.9.1 Introduction

Huge fluctuations in population size and flowering intensity are known to be common in orchids. Moreover, many orchid individuals can remain under ground for more than one year (Waite 1998, Willems and Melser 1998), and these factors make monitoring orchids a challenging task that can take many years. In Finland, *Epipactis atrorubens* is classified as Near Threatened (NT; Rassi et al. 2001) and the species is protected in both Finland and Estonia (Category III in Estonia). This three-year study attempted to answer several basic questions concerning the population biology of the species, and about how *Epipactis atrorubens* should be monitored. The study examined:

- Variations in population structure between years, areas and populations.
- Variations in the performance of plants (i.e. the number of leaves and the height of plants) between years and sites.
- Variations in reproduction between years and populations.
- Possible effects of the surrounding vegetation structure and population size on population structure, plant performance and reproduction.
- Current trends in the studied populations.
- The advantages and disadvantages of three different monitoring methods.

6.9.2 Biology and ecology

Epipactis atrorubens is an orchid that can grow up to 65 cm high, with many stems and long secondary roots arising from a short vertical rhizome. Because of this short rhizome, individuals are easy to identify. Between 1 and 16 ovate leaves per stem are arranged in two rows. Dark green and thick violet-coloured leaves reduce evaporation and protect plants against the high radiation levels typical of many of the species' growth sites (Korhonen and Vuokko 1987).

Epipactis atrorubens has 1–56 dark purple flowers in a single inflorescence, which is often partly one-sided. Flowering starts in the beginning of July in Estonia, and in the end of July in Finland. The species may be totally dependent on cross-pollination (Sundermann 1975, Bayer 1980, Claessens ja Kleynen 1996). Flowers are pollinated by insects, small wasps, ants and bumblebees, and propagation by numerous tiny seeds seems to be effective (Mossberg and Nilsson 1977, Claessens and Kleynes 1996, Ulvinen et al. 1998). Since vegetative propagation is not possible, new individuals are only established by seeds. After germination, young rhizomes are dependent on their mycorrhiza (Davies et al. 1988). The first roots appear in the second year of growth, and in the third or fourth year the first aerial shoots with green leaves can be seen (Korhonen and Vuokko 1987). After a few years the plants may no longer depend on mycorrhiza (Davies et al. 1988), and first flowers burst when the plant is ten years old (Mossberg and Nilsson 1977). Because of the existence of a rhizome, the vegetative phase (intrabud stage) in northern populations is longer, and plants grow more slowly than in southern populations, which helps them survive through the longer cold period (Batalov 1998).

The species grows in lime-rich soils, in habitats ranging from quite open and dry semi-open gravel slopes and dry pine forests to the shelves and terraces of calcareous rock outcrops. In Finland, a few sites are also found in moist herb-rich forests and rich pine fens. In Estonia, *Epipactis atrorubens* can also grow on rocky, sandy or gravelly seashores. The species requires plenty of calcium (Söyrinki and Saari 1980, Hämet-Ahti et al. 1998), but pure calcareous rocks are nutrient-poor, and the best growth sites are calcium-rich morains and the bottoms of calcareous rock outcrops, where other minerals release more nutrients (Vuokko 1983). In the north, the most typical growth sites are on the south or west sides of open slopes or cliffs, where conditions can correspond to more southerly circumstances.

6.9.3 Distribution

E. atrorubens has an extensive range from western Asia to Europe (Mossberg and Nilsson 1977, Kotilainen 1958). In the southern part of its range it is a mountain plant (Kotilainen 1958, Bauman ja Künkele 1982), but in Central Europe the plant typically occurs in sparsely wooded pine and broad-leaved forests, among *Juniperus*-vegetation, and on dry slopes and dunes (Kotilainen 1958). In Fennoscandia it can also grow in mountains as high as 1,200 metres above sea level (Kotilainen 1958). In Sweden and Norway, the plant is quite common in calcium-rich areas, and in it also occurs in some sites in eastern Fennoscandia (Ulvinen 1997, Ulvinen et al. 1998).

In western Estonia the species is quite abundant, but a few hundred inland populations have also been observed. In Finland *Epipactis atrorubens* grows in two areas; Juuka-Juankoski in eastern Finland, and Kuusamo-Salla in northern Finland. In Juuka it has been found in two areas (Hakalisto 1987) and in Kuusamo-Salla about 50 locations (Söyrinki & Saari 1980, Kokko and Ulvinen 1990, Jäkäläniemi 1993). Recently, two additional populations were found in southern Finland in roadside habitats (Ulvinen 1997). In Estonia, about one in four inland populations grow along the edges of roads.

6.9.4 Methods

Seven populations of varying population size and habitat type from Finland and one from Estonia were monitored during the period 1997–1999, and four populations in Finland were monitored during the period 2000-2002. The numbers of vegetative and flowering shoots were counted, their heights measured, and the numbers of leaves counted inside permanent 10 m x 10 m plots established where the densities of individuals were highest. At Hiiumaa, the heights of plants and the numbers of leaves were counted in five 1 m x 1 m squares, and shoots were counted over an area of 10 m x 10 m. At the Huosi Cliff site, the monitoring plot was 4 m x 5 m, and at Kiuta E the plot measured 10 m x 14 m. The numbers of flowers were counted on fertile individuals. Capsules were counted in some populations in 1999. The percentage coverage of canopy, herb, grass, litter and moss was estimated for each plot. Populations studied at Hiiumaa, Estonia are here described as the southern area of the species; populations from Northern Karelia (Polvela, Huosi Slope and Huosi Cliff) are included in the central area; and the rest of the populations in northern Finland (Kiuta SW, Kiuta N, Ampuma, Kiuta E) fall within the northern area of the species' range for the purposes of this study. It was not possible to measure all parameters at every site every year.

The monitoring method described above – where data is collected for each shoot inside survey squares and the co-ordinates of each shoot are recorded – is here referred to as the "shoot monitoring method". In the monitoring of northern populations, the same measurements were taken for each individual inside each survey square, according to the "individual monitoring method". The same data was additionally collected for permanently marked individuals in northern population, using the "marked individual monitoring method" during the period 2000-2002.

The life-cycle stage distribution of individuals can be obtained through individual-based monitoring methods. Individuals were classified into five stage classes according to their size. Individuals that did not appear after a year were included in the stage class *dormant*. Unfortunately, over the short time-scale of this study it was not possible to separate dead and dormant individuals. Individuals with a single shoot and a height of at least three centimetres were recorded as *small vegetative individuals*. All other vegetative individuals were classified as *large vegetative individuals*. The individuals in the *small fertile* class had one fertile shoot, and the rest of the fertile individuals were included in the class *large fertile individuals*.

Three different methods were thus used to collect data on northern populations of *Epipactis atrorubens* during the period 1998-2001 – the shoot method, the individual method, and the marked individual method – and the advantages and disadvantages of these methods were compared.

All statistical tests have been done using SPSS 10.0.5 for Windows (1999) standard version.

6.9.5 Results

Habitat desciptions

Vegetation coverages were measured for some populations (Table 1). In general, the sites were quite similar. The Ampuma site was the most distinct, having the densest field layer and few stones.

Table 1. Population size, canopy cover (%), scrub cover (%) and field and bottom layer coverage (%) at *Epipactis atrorubens* growth sites monitored in Estonia and Finland, 1997–1999.

Plot	Area	Pop. size	Canopy	Scrubs	Field layer	Grasses	Herbs	Bryophytes	Lichens	Litter	Bare ground	Rocks and stones
KIUTA SW	FK	18	20	18	48	2	16	26	1	12.5	4	10
KIUTA N	FK	165	15	6	42	4	11	24	7.5	11	4	11
AMPUMA	FK	245	16	8	53.5	12.5	20.5	30	1	12.5	0.5	5
KIUTA E	FK	17	21	14	31	4	5	25	4	17.5	11	11
POLVELA	FP	40	20		35	8	27			10	10	20
HUOSI Slope	FP	50										
HUOSI Cliff	FP	150	5	10	21	5	16			20		20
HIIUMAA	E	1000										

E = Estonia (southern population), FP = Finland, Central Finland (central populations), FK = Finland, Northern Finland (northern populations)

Population structure

There were no significant differences between the results obtained for different monitoring years inside the same populations, between the results from different areas, or among populations inside the central and northern areas in any of the density parameters studied (Friedman Test).

The densities of vegetative shoots have declined at the Polvela and Huosi Slope sites, increased at Ampuma and Kiuta E, and fluctuated at Hiiumaa and Huosi Cliff (Fig. 1a). The highest densities of vegetative shoots were found at Huosi Cliff. The densities of fertile shoots decreased in most populations, except in the Huosi cliff and Hiiumaa populations, where the densities of fertile individuals were highest (Fig. 1b).

The individual monitoring method revealed similar trends, but the values were lower. However, there was one exception, which could affect predictions of future trends. The number and density of fertile individuals at Ampuma increased, in contrast with the declining number of fertile shoots per survey square measured using the shoot monitoring method (Fig. 1c). The individual monitoring method additionally provided data on life-cycle stage distribution (Figs. 2a–2d, 1998-99). Large vegetative individuals dominated in all populations except Kiuta SW, where the number of small fertile individuals was the highest. Small vegetative individuals were absent from Kiuta SW and Kiuta E in 1998. Again, the use of the marked individual method provided data on the numbers of dormant and dead individuals (Figs. 2a–2d, 2000–2002). At Ampumavaara, small fertile individuals dominated. At Kiuta E and Kiuta N in 2000-2002 and in Kiuta SW in 2000, many individuals were dormant. At Kiuta SW most individuals were fertile, and no small vegetative individuals were observed.

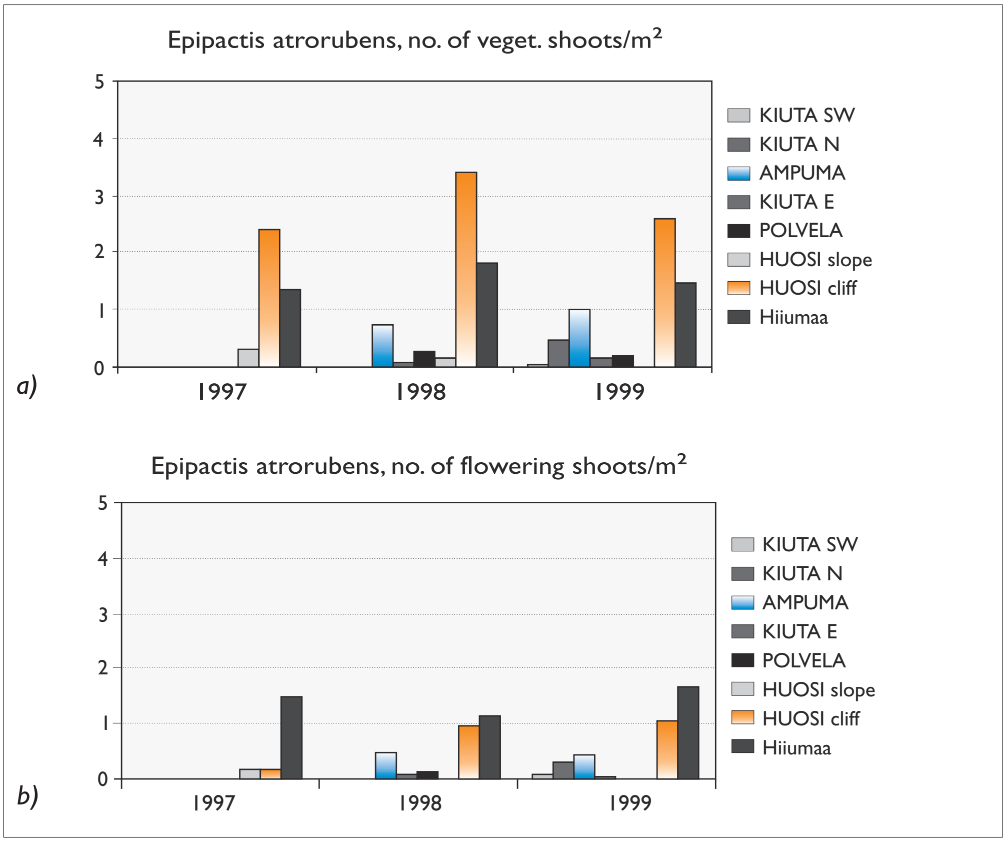

Figure 1. Densities of vegetative (a) and flowering (b) shoots per square metre in populations of Epipactis atrorubens, *1997–1999.*

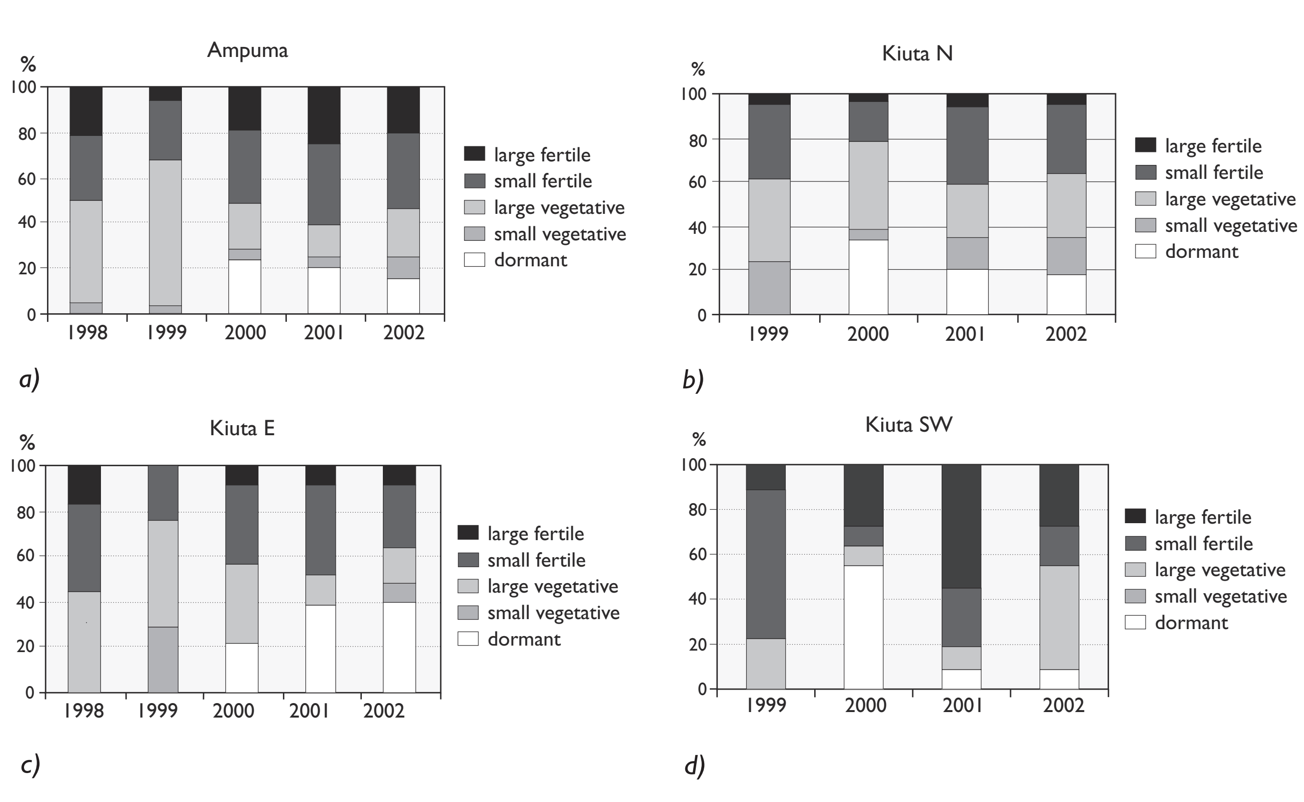

Figure 2. Life-cycle stage distributions of individuals in northern populations, mapped using the individual monitoring method, 1998–1999; and the marked individual method, 2000–2002.

The performance of plants

The results showed no significant differences in plant performance between monitoring years within populations (Wilcoxon Signed Ranks Test). While most parameters differed significantly between the northern, central and southern populations in 1998 and in 1999, almost all parameters were similar in populations in the central and northern areas (Table 2).

Although the heights of vegetative shoots were similar in all areas in 1998 and 1999 (Table 2), the heights of vegetative shoots at Ampuma in 1999 were considerably higher than in other northern populations (Fig. 3a, Table 2). Also, in 1997 vegetative shoots were very high at Huosi Slope. The heights of fertile shoots were highest at Hiiumaa and very low at Kiuta N (Fig. 3b). The heights of fertile shoots generally decreased during the research period.

The numbers of leaves were highest in the Estonian population for both vegetative and fertile shoots (Figs. 4a–b). In general, the numbers of leaves on both fertile and vegetative shoots were similar in the central and northern populations, and the fertile shoots had more leaves (Table 2).

The individual monitoring method showed similar trends, but values were higher, since the highest shoots and the shoots with the highest numbers of leaves have been taken into account. It also provided data on shoot distribution within individuals (Fig 5a–b). Thus, at Ampuma many more vegetative and fertile shoots were recorded per plant in 1998. Fertile individuals with more than one shoot were typical only of the Kiuta E and Ampuma sites. At Kiuta N, most fertile and vegetative individuals had only one shoot.

Table 2. Differences in plant performance between the southern, central and northern populations and within the populations in the central and northern areas (Kruskall Wallis Test).

	Chi-Square		
	Areas 1-3	Area 2	Area 3
Leaves/vegetative shoot 1997	23.50*** (df 1)	18.48***(df 2)	
Leaves/vegetative shoot 1998	48.11*** (df 2)	0.78 NS (df 2)	6.69** (df1)
Leaves/vegetative shoot 1999	105.61*** (df 2)	0.11 NS (df 1)	0.49 NS (df3)
Leaves/generative shoot 1997		1.34 NS (df 2)	
Leaves/generative shoot 1998	16.88*** (df 1)	2.37 NS (df 2)	0.78 NS (df1)
Leaves/generative shoot 1999	193.16*** (df 2)	1.03 NS (df 1)	1.13 NS (df3)
Height/vegetative shoot 1997		23.16*** (df 2)	
Height/vegetative shoot 1998	1.03 NS (df 1)	1.90 NS (df 2)	0.47 NS (df1)
Height/vegetative shoot 1999	1,55 NS (df 2)	2.11 NS (df 1)	62.33***(df3)
Height/generative shoot 1997	3.99* (df 1)	3.35 NS (df 2)	
Height/generative shoot 1998	9.66** (df 2)	0.38 NS (df 2)	3.61 NS (df1)
Height/generative shoot 1999	128.90*** (df 2)	0.90 NS (df 1)	16.44**(df3)
Flowers/shoot 1997		2.98 NS (df 2)	
Flowers/shoot 1998	1,85 NS (df 1)	8.06* (df 2)	2.53 NS (df1)
Flowers/shoot 1999	146.28*** (df 2)	1.10 NS (df 1)	1.06 NS (df3)
Capsules/shoot 1999	84.69*** (df 2)		0.42 NS (df2)

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, NS = not statistically significant
1 = southern area, 2 = central area, 3 = northern area

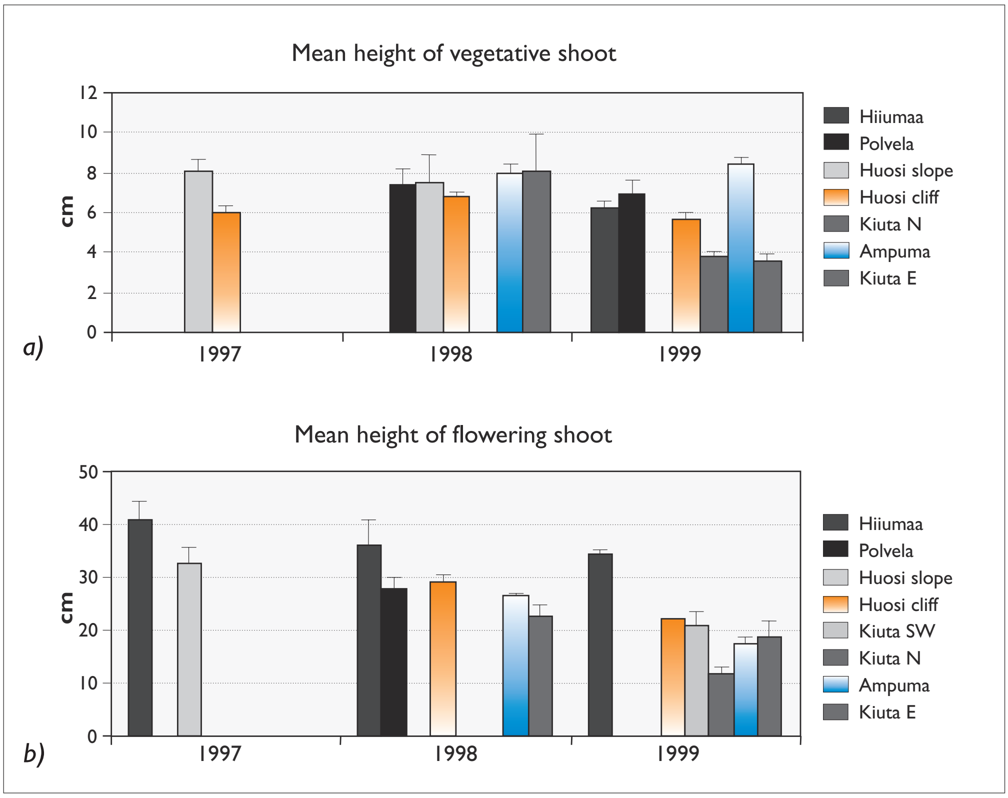

Figure 3. Mean heights (±SE) of vegetative shoots (a) and fertile shoots (b), 1997–1999.

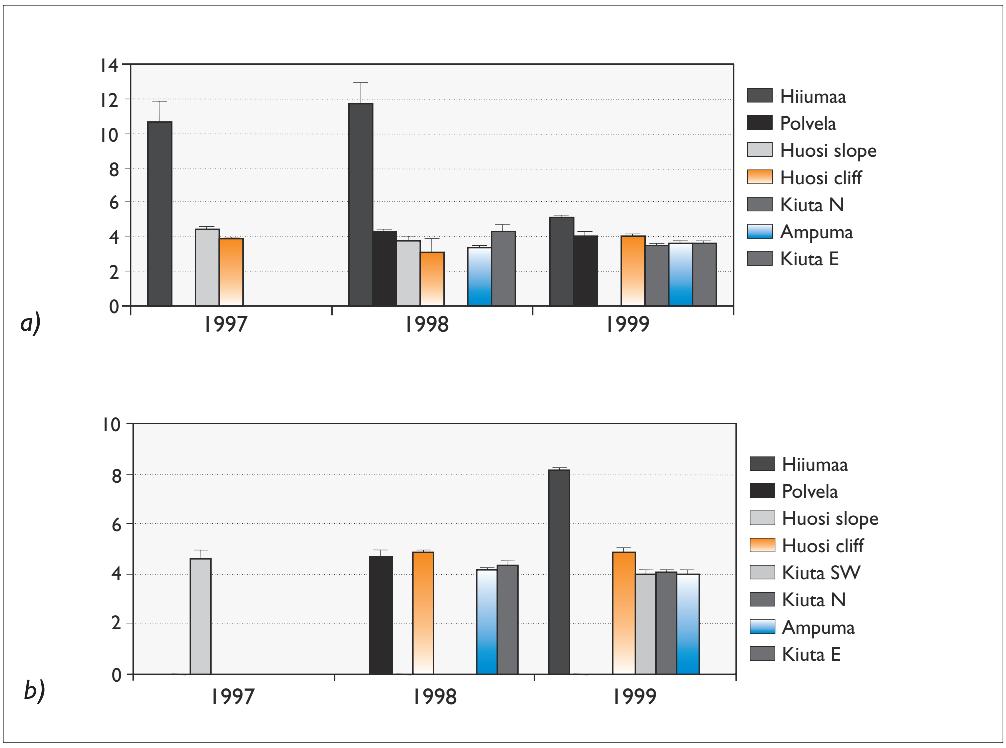

Figure 4. Average numbers (± SE) of leaves on vegetative shoots (a) and fertile shoots (b), 1997–1999.

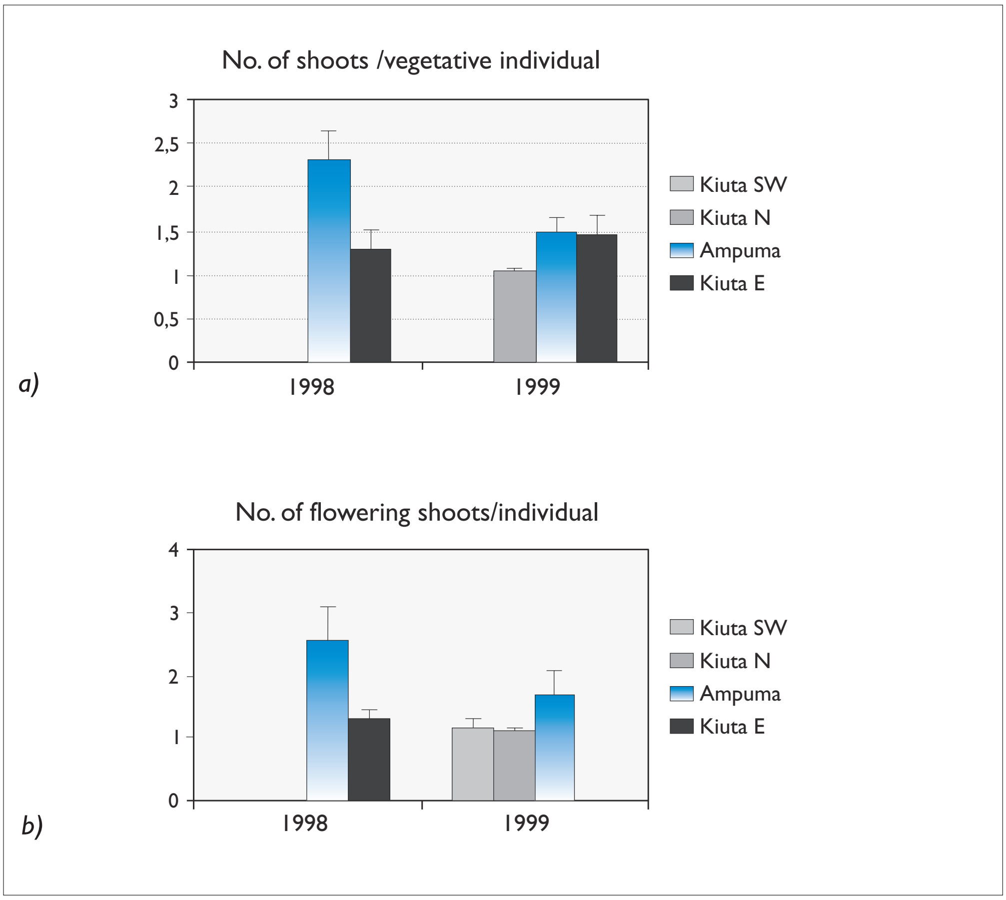

Figure 5. Average numbers of shoots in vegetative individuals (a) (± SE) and fertile individuals (c) (±SE), 1998–1999.

Reproduction

No significant differences were observed in reproduction rates between the monitoring years within populations (Wilcoxon Signed Ranks Test). While most of the other studied parameters differed between the areas, the numbers of flowers per shoot in 1998 were similar for all three areas. However, there were differences in the numbers of flowers per shoot in 1998 among the central populations. The other reproductive parameters did not differ between the populations in central and northern areas.

In general, the number of flowers per flowering shoot was highest in the central populations, but particularly high figures were recorded at Hiiumaa in 1999 (Fig. 6). Capsule production was 50% at Hiiumaa, while at other sites it was 15–25% .

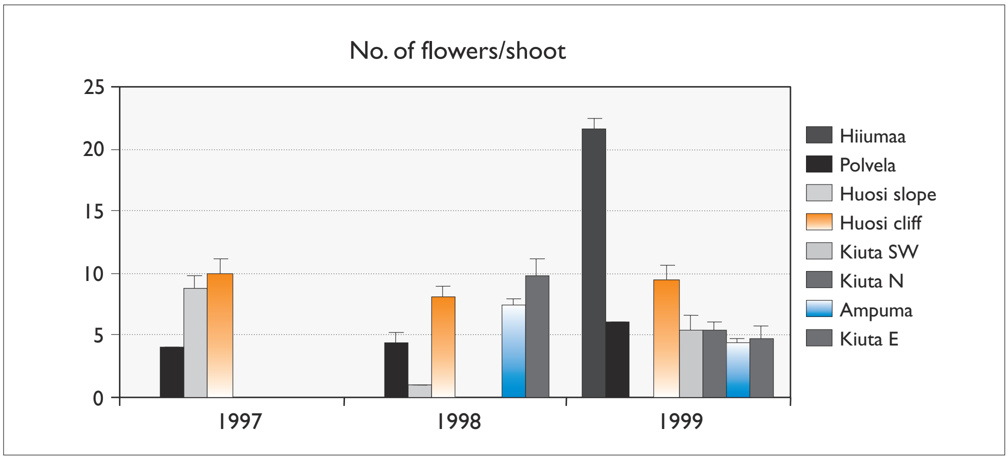

Figure 6. Numbers of flowers per flowering shoot (±SE), 1997–1999

Effects of population size and vegetation structure

Combined data from all the populations was used to analyse the effect of vegetation structure on other parameters. Most of the coverage figures had little effect on any parameters where data was sufficient for analysis (Table 3). However, in large populations the densities of flowers and vegetative shoots were higher than in small populations in 1999. Vegetative shoots were also higher in sites with high grass coverage in 1999. Additionally, densities of fertile shoots measured in large populations in 1999 were considerably higher where the field layer was dense.

Table 3. Effects of vegetation coverage types and population sizes on studied parameters for all populations. Only significant relationships are presented (Multiple Regression Analysis).

Dependent parameter	Predictor	R^2	t
Vegetative shoots/m^2 1999	Population size	0.934	5.300*
Generative shoots/m^2 1999	Population size	0.988	12.861**
	Population size and coverage of field layer	0.999	170.377**/26.013*
Flowers/ m^2 1999	Population size	0.966	7.553*
Height/vegetative shoot 1999	Coverage of grasses	0.999	22.709*

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Population dynamics

The marked individual monitoring method enabled estimates to be made of the dynamics of populations. The results presented here are all from the Ampuma site. Assessment of the transitions of plants from one stage to another showed that most plants tend to remain at the same stage from year to year, and that the highest proportion of dormant/dead plants were previously large vegetative individuals (Table 4). Seedling germination was not abundant, with only three plants germinating during the period 2000–2001, and eight from 2001–2002. From this data, it would be possible to calculate population growth rates, stable stage distributions and reproductive values of populations by using matrix modeling. Since the monitoring period of three years and two transitions is not enough to distinguish dormant individuals from dead individuals, these demographic parameters have not been calculated here.

Table 4. Transitions between life-cycle stages observed in the *Epipactis atrorubens* population at Ampuma, 2000–2001 and 2001–2002. Dead and dormant individuals could not be distinguished.

	2000				
2001	Dormant/dead	Small vegetative	Large vegetative	Small generative	Large generative
Dormant/dead	0.179	0.250	0.265	0.091	0.030
Small vegetative	0.036	0.625	0.029	0.022	0.055
Large vegetative	0.500	0.000	0.235	0.036	0.000
Small generative	0.286	0.125	0.412	0.673	0.030
Large generative	0.000	0.000	0.059	0.200	0.939
	2001				
2002	Dormant/dead	Small vegetative	Large vegetative	Small generative	Large generative
Dormant/dead	0.263	0.300	0.208	0.115	0.091
Small vegetative	0.000	0.600	0.083	0.040	0.126
Large vegetative	0.447	0.100	0.458	0.098	0.091
Small generative	0.263	0.000	0.208	0.672	0.114
Large generative	0.026	0.000	0.042	0.082	0.705

6.9.6 Discussion

Survival of populations

According to the results of this monitoring, the Estonian population is most likely to survive, since it has numerous shoots and produces high numbers of flowers and capsules. The central populations are quite small, and thus vulnerable to unfavourable fluctuations in environmental conditions. The most viable central population seemed to be the Huosi Cliff population, where increasing numbers of flowering shoots were observed. The population size at Huosi slope was small, however, and no fertile individuals were observed in 1998, so it may be on its way to extinction. Data on life-cycle stage structure indicates that the two northern populations currently producing seedlings (Ampuma and Kiuta N) should be viable. Although capsules were maturing normally at Kiuta E and Kiuta SW, there was little or no seedling production, and populations with such population structures can rapidly become extinct.

Data on environmental variables was too limited to draw any reliable conclusions on their effects on the other studied parameters, but large population size unsurprisingly seems to have a positive effect on viability.

Plant performance

In general, data on plant performance showed considerable variations between areas for almost all parameters, and also variations between the populations in the same area. The heights of vegetative shoots exhibited the least variation. Variations in the level of herbivory, climate and pollination success could be reasons for such discrepancies. It should also be noted that the heterogeneity of the data obtained from different sites hampered comparisons, since data was not collected for all parameters at every site every year.

Comparison of the different monitoring methods

The shoot monitoring method only produced limited information on real fluctuations in population sizes, which is one of the main aspects of interest. This was particularly evident at Ampuma, where counting shoots indicated that numbers were decreasing, while counts of individuals showed an increase in population size. Furthermore, counting shoots only produced information on population structure at the shoot level, where a few large individuals can greatly influence results. The co-ordinates noted for the shoots also varied because of slight changes in the borders of the plot between the monitoring years, so comparisons of shoots between different years were not possible.

By counting individuals, it was easier to locate individuals from year to year. However, this was not as accurate as the marked individual monitoring method, because many individuals were missed, especially in dense populations, and it was particularly difficult to locate dormant individuals. One advantage of the method was that it provided information on the number of individuals at different life-cycle stages. Information on seedlings was particularly valuable as an indicator of population structure and development.

Variations in population structure and dynamics could be best seen from the data collected for marked individuals. Field studies conducted over a few years will produce data on the stage distribution and transitions between the stages, making it possible to calculate demographic parameters for populations, such as finite growth rates, stable life-cycle stage distributions, and reproductive values for each life-cycle stage (Caswell 2001). Finite population growth rates provide a measure of the average fitness of a population living in a given environment. The huge differences within stable life-cycle stage distributions and observed distributions indicate the great variability in population dynamics. The reproductive value of each stage represents the predicted value of an individual of that stage as a parent.

The amount of time needed for monitoring using each of these methods was quite similar. For the shoot monitoring and individual monitoring methods, most of the time was spent on measuring co-ordinates, because it was so hard to locate the same shoot or individual every year. In the marked individual monitoring method, the establishment of the monitoring site was quite time-consuming.

Monitoring of *Epipactis atrorubens*

The main aims of such monitoring should be to enable predictions for the future of populations, and to separate natural fluctuations from changes induced by man. Precise data on individuals can be collected from a sample of populations and habitats taken from each distinct distribution area. Monitoring of the same individuals for a period of 5-10 years can produce reliable estimates for the fluctuations in population structure and dynamics, and the viability of populations. Seedling recruitment rates and individual mortality rates are particularly important, although it takes time to distinguish dead plants from dormant individuals. Of the three methods used here, the marked individual monitoring method gave the best results. Where *Epipactis atrorubens* is concerned, a monitoring plot size of 10 m x 10 m is highly suitable. The life-cycle stages of plants are studied each monitoring year, with new seedlings marked, and the numbers of flowers or capsules counted for each plant. Capsule production is a good indicator of the fecundity of fertile plants, and can also show how successful pollination is in different environments. Dormant or dead individuals can be more easily found if two extra notes are recorded on the location of each plant: the quarter of the survey square and the group of individuals to which the plant belongs.

In general, the heights of plants seem to correlate well with reproduction rates and environmental conditions, so this easily measurable variable could be used as an indicator of habitat quality and environmental change. Measuring additional general environmental factors (e.g. the amount of light, canopy cover, scrub density, coverages of field and bottom layers) at ten-year intervals would give useful data on habitat changes over longer periods. More attention should also be paid to the frequency of different kinds of herbivory (e.g. mammals, insects) and other damage (e.g. trampling) observed in different parts of plants. This should also help to ensure that other parameters are not measured from partly eaten or damaged individuals.

6.9.7 References

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6.10 Neotinea ustulata *(L.) R.M. Bateman, Pridgeon & M.W. Chase* (Orchis ustulata *L.*)

English: Burnt tip orchid
Estonian: Tõmmu käpp
Finnish: Palokämmekkä

Kadri Tali

6.10.1 Introduction

Neotinea (Orchis) ustulata is a small-flowered but attractive terrestrial orchid. The species is distributed widely across central and Mediterranean Europe into Eurasia, but is nowhere common. It is a good indicator of species-rich calcareous grasslands, but is declining in numbers throughout its range. *Neotinea ustulata* is classified as care demanding in the Estonian Red Data Book (Lilleleht 1998), and is protected in Category II (see page 14). This study examines the results of the long-term monitoring of *N. ustulata* plants by means of individual tagging and mapping.

6.10.2 Distribution

N. ustulata grows on the Faroe Islands, in England and in Denmark. The northern boundary of its range passes through Öland, Gotland, Estonia, and along the southern shores of Lake Ladoga and the Rivers Vjatka and Kama. The species has also been found in the Urals and on the plains of western Siberia (Baumann & Künkele 1982; Vakhrameeva. 1991).

The southern edge of its range runs through Northern Spain and along the Mediterranean coast of France. *N. ustulata* grows on the Apennine Peninsula north of Rome, on almost the whole of the Balkan Peninsula and probably in the southern Ukraine up to the Volga River (Füller 1983); while it also occurs in the Caucasus (Vakhrameeva 1991). The species is declining and is protected throughout its range. It is sometimes abundant in mountains, but rare elsewhere, and very rare in the Mediterranean region (Delforge 1995).

In Estonia *N. ustulata* has been documented in about 33 localities since 1971 (Kull, Tuulik 2002); although it was previously found in over 70 localities. The species is more frequent on the islands and in the western part of the country, as is the case with most orchids in Estonia, but there are also populations in northern and central Estonia. Most populations consist of only about 10-20 plants and few contain more than 100 individuals.

6.10.3 Morphology and biology

Neotinea (Orchis) ustulata is a short-lived species with 1–2 or occasionally 3 ovoid or ellipsoid tubers positioned 3–6 cm underground. Stems are typically 10–20 cm long, although they can vary from 5–50 cm in length, and usually slender and erect. Two to six unspotted bluish green leaves form a rosette. The spike is compact, dense, and 1–10 cm long. Flowers open from the base upwards and the 5–10 uppermost dark purple buds often remain unopened. The labellum measures 4–8 mm, and is deeply trilobed, and coloured white or pale pink with papillose purple spots.

The species produces no nectar and is pollinated by a tachinid fly (Diptera, Tachinidae). Capsules are about 1 cm long, and erect. Seeds are dust-like and very numerous, and can be dispersed over long distances.

In 1988, Kumpel distinguished two varieties of *O. ustulata* (*ustulata* L. and *aestivalis* Kümpel) that differ in their phenology, with *aestivalis* flowering about 1-2 months later than *ustulata*. These varieties were reclassified as subspecies in 1990 by Kümpel and Mrkvicka on the basis of somewhat debatably distinct morphological characteristics.

The first rosettes start appearing in autumn after a resting period of approximately two months after flowering (in September-October for early-flowering plants and in October-November for late-flowering individuals). Plants remain green during the winter, and more plants emerge in spring. Flowering begins in May or June in early-flowering populations, and in July in late-flowering ones. Flowering lasts for 2–3 weeks, but as not all the plants begin to flower simultaneously, in favourable years (i.e. with enough moisture) flowering plants can be detected over a period of 4–5 weeks in most populations. Rosettes start to turn yellow at the beginning of flowering, by which time many vegetative plants have also disappeared. After flowering, plants that do not bear fruits wither. Fruits ripen and capsules open in August or September.

Neotinea (Orchis) ustulata is characteristic of species-rich calcareous grasslands. It is favoured by sunny, open habitats; but also can inhabit light, open woodland. The largest populations are usually on old moderately grazed pastures which have never been treated with artificial fertilisers, herbicides, or pesticides. The species is sensitive to the presence of a dense old grass layer, and disappears quickly from abandoned pastures where juveniles can no longer germinate.

6.10.4 Monitoring methods

In Estonia, monitoring of *N. ustulata* was started at two sites in 1993, and three more plots were added in 1994. The Aljava, Lõetsa and Kapi populations (all on Muhu Island) contained only early-flowering plants, and the Sillukse and Jäneda populations (on the mainland) were exclusively late-flowering.

The permanent plot monitoring method was used in both sites, while additionally every single plant was marked and mapped to allow the fates of individual plants to be monitored. As the material collected was also used for population dynamics research, the methods used were more complicated than those required for the monitoring project alone.

In each population, 10 permanent 1m x 1m plots were established to map all vegetative and generative plants. In most localities, the survey squares were not adjoining, and their exact position depended on the gregariousness of the plants. Since 1998 a new 1m x 1m plot has been set up at each site, as plants disappeared from old plots and new plants sprang up outside the original plots.

Each locality was visited during peak flowering each year during the period 1993–1995, and since 1996 at least three times a year. The height of each inflorescence and the numbers of leaves and fruits were recorded every year. Since it is practically impossible to distinguish between juvenile plants and weaker vegetative plants, all non-flowering rosettes were considered as vegetative.

6.10.5 Results

Populations

The Aljava population is situated on Muhu Island on seashore pasture, 3–4 m above sea level. The pasture has been abandoned for 6–7 years, and although there are no trees or scrub, the old grass layer is very thick.

The Lõetsa population is also on Muhu Island, not far from the sea, 10–12 m above sea level, next to a former gravel quarry, on an abandoned village pasture that has become overgrown with large junipers and young pines.

The Kapi population is situated in the middle of Muhu Island, 18–19 m above sea level, on a site where lime was formerly burnt. The soil is very thin and stony, and the site has become overgrown by young pines within last five years.

Sillukse is an area of open woodland in western Estonia, 11–12 m above sea level. In 1996 a quarry was dug in the area, and a large part of the local *N. ustulata* population was destroyed. Half of the monitoring plots still remain, but they are situated right next to the quarry and frequently suffer from trampling.

The Jäneda site currently contains the easternmost *N. ustulata* population in Estonia, which grows on a former village school sports ground, 79 m above sea level. The area has been overgrown to some extent by mixed forest, but this has been cleared a little in recent years.

Plant performance

In all populations the numbers of above-ground plants and the numbers of flowering plants varied greatly from year to year (Fig. 1). The flowering percentages were highest between 1994 and 1996, with the exception of a high flowering percentage observed in 1997 in the Jäneda population. The summer of 1999 was dry (with precipitation of 28.3 mm compared to the normal 49.9 mm) and flowering was inhibited in most populations.

The heights of flowering plants varied from 5 cm to 37 cm for the early-flowering plants, and from 10 cm (with a single exception measuring just 3 cm) to 50 cm for the late-flowering plants. In general, tall spikes were associated with wet (and warm) springs. Fluctuations in heights within single populations in different years were larger than the differences between the populations.

Population structure and dynamics

Individual plants were in general short-lived. Just six of the 40 plants marked in 1993 in the late-flowering Sillukse population, and three of the 24 marked plants in the early-flowering Lõetsa population were still present in 2000.

The numbers of above-ground plants have fluctuated in all the populations. Plants that emerged, flowered only once and then disappeared, had a large influence on the dynamics of the populations. In 1995, 64 new plants emerged in the Aljava population, but none of them ever appeared again. Survivors show a range of behaviours: with the length of dormancy and the length of flowering varying a great deal from plants being vegetative all their life, to plants flowering all their life.

Figure 2 shows the maximum number of successive flowerings that the monitored plants managed to produce. The number of plants that never flowered varied between the populations, and in every population most plants flowered just once during their lifetime.

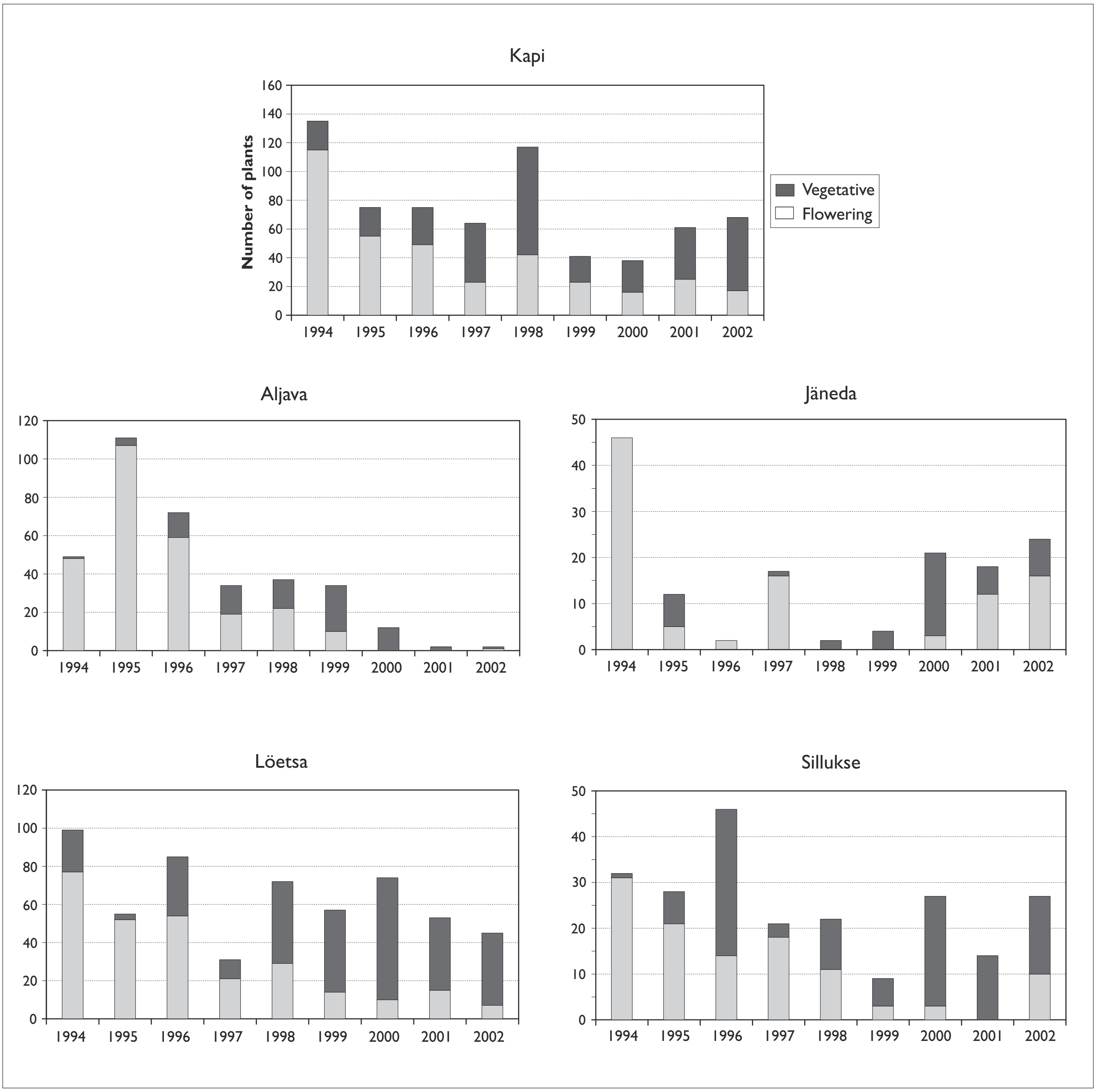

Figure 1. Dynamics of the above-ground Neotenia ustulata *plants in five monitored populations.*

The phenomenon of dormancy is well exhibited in *N. ustulata*. More than 70% of the survivors, i.e. the plants that lived for longer than 1–2 years, exhibited dormancy at some stage during their lifetime. The largest number of plants in most populations has been dormant for one year, a smaller number for two years, and less than 10% of the plants remained dormant for three or four consecutive years (Fig. 3). It is possible, however, that the four plants recorded as dormant for 5 and 6 years may have been vegetative in spring of 1997, since the survey was carried out so late that year that some vegetative plants may have flowered earlier and unnoticed, subsequently withering before the full flowering of the rest of the population.

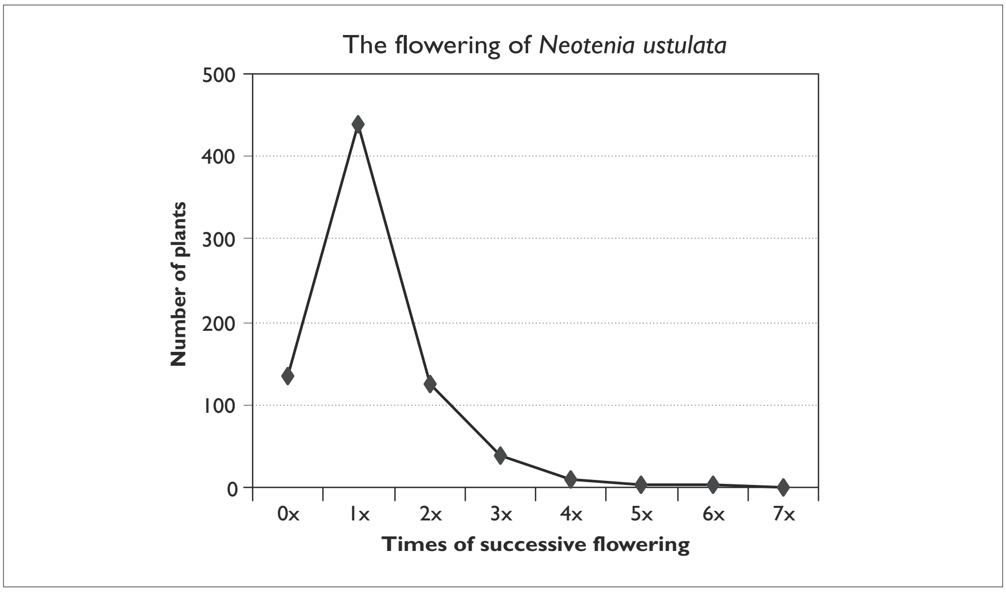

Figure 2. Maximum number of successive flowerings for individuals from all study populations of Neotenia ustulata.

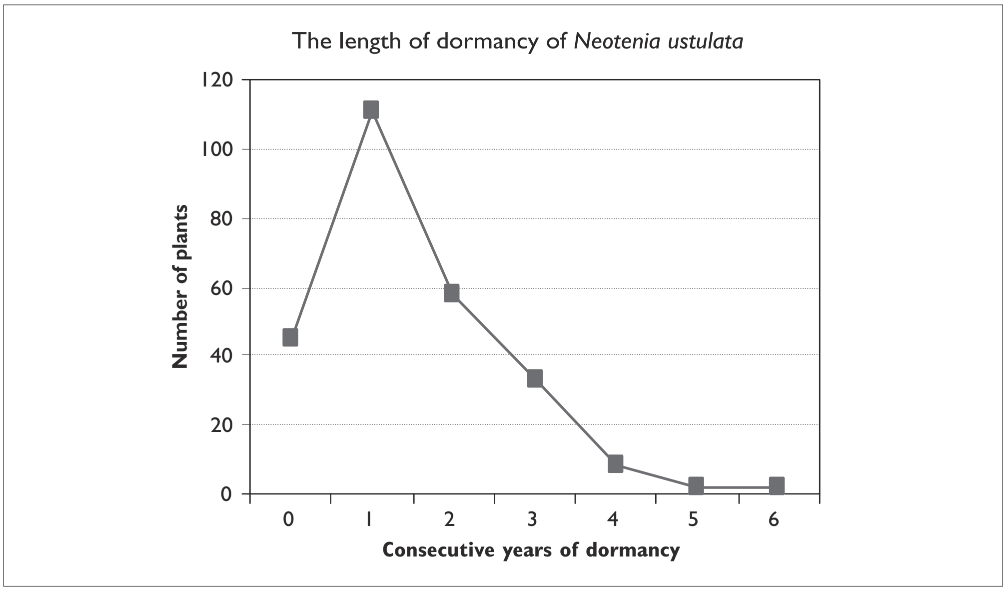

Figure 3. Lengths of dormancies summarised for all study populations of Neotenia ustulata.

All possible transitions occur between the vegetative, generative and dormant stages. The most likely eventuality for all populations is that a plant becomes dormant the next year after flowering.

In most populations, with the exception of Kapi, the biggest percentage of dormant plants flowered on their reappearance. Vegetative plants that appeared after some years of dormancy often produced small two-leafed-rosettes.

Reproduction

Unlike other non-rewarding orchids, the fruit set of *N. ustulata* is not small (Ackerman 1989; Calvo 1993); indeed percentages as large as 80 and 100 can be observed where there are very few flowering plants in a population (Table 1).

Table 1. Fruit-bearing plants as a proportion of flowering plants (%) in all populations.

	1994	1995	1996	1997	1998	1999	2000	2001	2002
ALJAVA	8.3	1.9	0.0	31.6	4.5	80.0	-	-	0.0
LÕETSA	22.1	21.2	29.6	9.5	0.0	7.1	10.0	6.7	0.0
KAPI	56.5	5.5	4.1	0.0	2.4	26.1	12.5	12.0	5.9
JÄNEDA	17.4	60.0	100.0	6.3	-	-	0.0	25.0	0.0
SILLUKSE	25.8	52.4	35.7	11.1	45.5	0.0	33.3	-	10.0

Juveniles were difficult to detect, and new plants rarely sprang up next to the older plants within monitoring plots. Often new plants could be found on sites where the soil had recently been disturbed (by wild boars, or other animal trampling etc.).

6.10.6 Discussion

It is important to examine plant performance in wild populations in order to reveal any changes in endangered or rare species. It must also be remembered that natural fluctuations may be large, and population trends may not be visible over just a few years of basic monitoring. Over the period 1994–1999, the numbers of non-dormant plants in all populations showed a clear decrease, but since improvement shave occurred in all populations except Aljava over the last couple of yearsome improvement, it is possible that these changes are largely due to the natural fluctuations characteristic to this species.

The presence of many dormant plants may easily lead to the underestimation of the size of populations. Foley (1987, 1990) has studied the populations of *N. ustulata* in England, and noted that even in favourable years, more than 50% of the plants were in the dormant stage. This proportion was not so large in Estonia, but in some years the presence of many dormant plants in populations greatly influenced the monitoring result. Depending on the biology of the species, it may be important to visit monitoring plots more than once during a single season. In the case of *N. ustulata*, most vegetative plants are missed if the visit is timed too late.

In monitoring plants that grow sparsely and are not long-lived, monitoring transects 2–5 m wide covering most of the population could be proposed instead of more limited plots. Individuals should be marked and/or mapped along these transects. Transects give a better idea of the age structure and rejuvenation processes in the population. The decision on whether to use mapping, marking or both, depends on the landscape, the other vegetation, and probably most of all on the amount of human impact on the site. Tags may be removed by passers-by unaware of their significance, while some animals seem to like to chew plastic. Nevertheless, large colourful tags are especially valuable at sites with long grass and dense scrub. Mapping alone is usually too inaccurate even within small plots, and is not advisable for transects even where tagging is impossible.

During the first monitoring years (of a species or a population), more emphasis should be put on phenology. It takes more than one visit to discover the optimal time for monitoring, and to assess whether just one visit a year would be enough subsequently. In the case of *N. ustulata*, the best results can be achieved with three visits: the first to count all plants before flowering; the second to count flowering plants (by then many vegetative plants will have disappeared); and the third to count the fruit capsules.

In the case of this species, monitoring can be made more straightforward and cost-effective by not recording plant heights and the numbers of leaves. The differences between these figures are largely due to annual fluctuations, and do not reflect the overall state of populations.

6.10.7 Recommendations for habitat management

Like several other orchid species, *Neotinea ustulata* prefers semi-natural habitats, and is therefore fairly dependent on human activities. Grazing is the best way of managing the populations of this species, since while animals keep the grass layer down to a suitable level, their trampling also breaks up the soil, allowing seedlings to establish themselves. As this 9-year-long monitoring study reveals, the overgrowth of habitat with trees and scrub is not as dangerous for this species as the presence of an uncut layer of old grasses. In four populations where sites have become at least partly overgrown with pine, *N. ustulata* still occurs in reasonable numbers, whereas in Aljava, where there is no problem whatsoever with scrub, the population shows clear signs of decline. Management is urgently needed at sites where young plants cannot establish themselves because of a dense grass layer. Cutting down trees and bushes is also important where they grow densely, but such measures are not so urgent. If sheep or cattle cannot be returned to graze a site, haymaking is another very good option, although in this case flowering times must be taken into consideration – in early-flowering populations mowing should not take place earlier than July, whereas late-flowering populations should be mown either in August or in June. These plants tolerate mowing in spring and early summer surprisingly well.

6.10.8 References

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7 Conclusions

Monitoring threatened species successfully is a very challenging task. Vascular plants are supposed to be one of the easiest groups of organisms to monitor, but many complicating factors still have to be considered. Above all, the importance of fully understanding the biology and phenology of the target species cannot be overestimated. Without this knowledge, monitoring may produce misleading results and false interpretations of the actual events in monitored populations.

Surveyors need thorough and unambiguous instructions before they can obtain reliable, comparable and reproducible information from the monitored populations. Before such instructions are issued, their functionality should be properly tested in the field, to avoid wasting time on irrelevant and unfeasible measurements. Although general instructions for monitoring must be given, monitoring regimes must also incorporate species-specific and site-specific solutions. Furthermore, monitoring should not be seen as a permanent and unchanging routine, but as a process where practices and methods can be subsequently changed according to the needs of conservation. Producing a long time-series of observations should not become an end in itself.

Several useful points to be taken into account in planning monitoring regimes can be inferred from the case-studies within this report.

Selecting populations for monitoring

For rare species with very few populations, all populations may be monitored. But where a species is found in perhaps as many as several hundred sites, some kind of selection procedure is necessary, because resources are seldom sufficient to allow all populations to be monitored (see *Cypripedium*, p. 71, 76). The next step is to determine an adequate sample size, and to decide whether the sample be randomly selected. There are practical arguments against selecting populations at random. Monitored populations should be located so that reaching them is not too time-consuming. The selection should also be geographically representative, and cover populations both from the centre and the edges of the species' range. The monitored populations should also represent a variety of different situations: e.g. populations in natural, managed and disturbed habitats; both large and small populations; and populations inside and outside protected areas. Factors affecting populations are often site-specific, so it is unreliable to extrapolate monitoring results from a small number of populations to produce figures for many populations.

Among the monitored populations there should also be *reference populations*, which are viable, regenerating populations, in habitats of natural or optimal condition for the species to grow and reproduce. Monitoring data from such populations can give reliable and comparable data on the natural fluctuations in populations, death and birth rates, population structures, and the frequency and optimal conditions for seedlings to become established and to survive. As statistically relevant experiments are rarely possible in very small populations, such reference populations can serve as model populations for comparison with managed populations.

Permanent plots or not?

In most of our case studies, permanent plots of approximately 10 m x 10 m in extent were in use. There was some variation in the sizes and shapes of plots, depending on the scale and extent of the population concerned. The use of permanent monitoring plots has both advantages and disadvantages, which have to be weighed up for each case or species. The benefits of plot monitoring are numerous: the area monitored remains the same from year to year; "empty" squares are examined more thoroughly (see case study 6.8, *Epipactis palustris*, p. 79); and fixed plots can be clearly marked and more easily found by surveyors who have not visited the site before. Moreover, the collection of basic environmental data is more straightforward on permanent plots.

The disadvantages of permanent plots are obvious in some cases: the populations of certain plant species simply do not remain within the marked plots but "shift" to another area. This is especially true for annual plants (e.g. *Rhinanthus*, p. 48), but also for some short-lived perennials (e.g. *Neotinea*, p. 99). Furthermore, in large populations it may be difficult to establish plots that accurately reflect the variable conditions over a whole site – in such cases several plots should be established (see *Epipactis palustris*). The spatial structure of a population may also hamper the establishment of permanent plots. Where individuals are scattered around a wide area, for example, a single plot may only contain a very small proportion of all the individuals within a population (see *Pulsatilla* p. 37).

In some cases, population data was collected from both permanent plots and the whole area of a population, in order to compare these results. In the case of *Ligularia* (p. 54), for example, there was no significant difference between the observed trends inside the plot and those noted for the whole population. If the conditions within a site are homogenous, plot monitoring can give reliable results which sufficiently reflect trends in the population as a whole.

Permanent plots are especially recommendable for long-lived perennial plants and plant species whose biology and behaviour are not fully understood. Plots are also useful in cases where only shoot densities are to be recorded. Even where permanent plots are in use, whole populations should be examined every now and then.

Marking individuals

This project did not focus closely on individual-based demographic monitoring, although such methods were used in some cases (e.g. in the *Cypripedium*, *Neotenia*, and *Epipactis atrorubens* case-studies). Demographic monitoring undoubtedly gives a better understanding of the dynamics of populations, but there are cases where individual-based monitoring is too laborious for pure monitoring purposes, and it may even be completely futile. When studying vegetatively spreading plants, for instance, marking and monitoring single "plants" or shoots does not give any useful information (e.g. *Epipactis palustris*). Similarly in the case of *Agrimonia* it was difficult to monitor changes in marked individuals because of the plants' effective vegetative growth.

On the other hand, for species where individuals are easy to define, monitoring should be based on counting individuals rather than just shoots (see case-study 6.9, *Epipactis atrorubens*, p. 87). In such cases, collecting individual-based data does not necessarily involve any extra work.

Using size/age/stage classes

When examining and monitoring plant populations, some kind of size-based or stage-based classification should always be in use. Several years of demographic monitoring may be needed before a reasonable classification system can be designed. Even where this has not yet been possible, simple trials to establish a rudimentary classification system are worthwhile, since even such basic systems are better than no classification at all. The minimum requirement in all cases is to distinguish individuals or shoots according to whether they are vegetative or flowering – with juvenile plants or seedlings also identified if possible. Size classifications may also give good information on the general condition of a population.

For the purposes of these case-studies, it was easy to design size classification systems for *Ligularia sibirica* and *Epipactis atrorubens*, for instance, since in both cases individuals are easy to distinguish, and it is also easy to count and distinguish vegetative and generative shoots. In the case of *Pulsatilla* it proved to be difficult to make a size classification, as old plants seem to shrink due to degeneration, so the abundance of small vegetative plants can easily be interpreted wrongly. In the case of *Pulsatilla*, it was more useful to set up a simple stage classification (generative/vegetative plants), and it was also possible to identify one-year-old juvenile plants.

Some *Agrimonia pilosa* (p. 63) populations contained many small vegetative shoots, which remained small for a long period of time. These were not in fact seedlings, as was first believed, so they do not directly reflect the regenerative capacity of the population. It is possible that these shoots form some kind of vegetative "shoot-bank" which may later start growing in more favourable circumstances. However, the significance of these small vegetative shoots is still not clear, so care must be taken in interpreting the related monitoring results.

Measuring morphological characteristics

The usefulness of measuring and counting various features of plant individuals has to be considered thoroughly before the actual work is commenced. Some morphological measurements can be useful, if their significance and relationship to such factors as regenerative capacity is well understood. However, the benefits of measuring morphological features are questionable in many cases. In the case-studies presented here, for instance, measuring the height of *Ligularia* plants did not reveal anything about the condition of the plants. In dense vegetation, the shoots of *Ligularia* may grow high, but have fewer flowering shoots than shorter plants growing in open conditions. In the cases of *Epipactis palustris, E. atrorubens* and *Cypripedium,* variations in the numbers of leaves were so small that they could not indicate anything about the viability of the plants. With *Pulsatilla patens*, there appeared to be no benefit from measuring the heights of plants, as plants continue growing until the seeds ripen.

For monitoring purposes it is much better to concentrate on counting easily recorded features which truly reflect the viability of a population, such as the numbers of shoots, flower-heads or seed capsules, depending on the plant species concerned. When conducting more laborious monitoring surveys, it may be enough merely to record the *presence* of viable seeds, instead of counting them all. Recording the simple presence or absence of seedlings and juveniles is ultimately a much more important factor in considering the viability of the population.

Timing of monitoring

Timing monitoring appropriately is crucial in terms of the reliability of the results. This requires good information on the phenology of the plant – including information on other stages of the life-cycle than flowering. For example, individual *Pulsatilla* plants have often been counted during flowering, when they are easily found. However, this is too early for vegetative plants to be surveyed, because the plants' leaves only emerge after flowering. Thus, the numbers of plants recorded during flowering are much lower than later in the season (see case-study 6.2, *Pulsatilla*, p. 37).

Neotinea is a wintergreen plant that exhibits phenological differences between flowering and vegetative plants. In order to record both vegetative and generative individuals, populations must be monitored twice: once in early spring when the vegetative plants are still green, and then again later in summer when the flowering plants have appeared, and the vegetative plants have withered.

Monitoring of *Agrimonia* (p. 63) could be timed to coincide with the end of flowering. Flowering may last for several weeks, and the first fruits ripen before the end of flowering. After flowering, the shoots tend to fall down, which makes them difficult to find and count. In the case of *Epipactis palustris* (p. 79), flowering may also occur too early for the smallest vegetative shoots to be discernible, so monitoring could be timed for when capsules ripen.

If it is only possible to visit a site once during a single growing season, the date when the seeds ripen might be the most recommendable. On the other hand, if the aim is to relocate a "lost" population or seek out undiscovered populations, surveying during flowering – when plants are much easier to detect – would obviously be preferable.

Dormancy

Many perennial plants have the habit of dormancy – spending a year or two underground. This may lead to misinterpretations of monitoring results. A period of demographic monitoring would be useful with such species, in order to work out the length and frequency of dormancy – so as to determine how large a proportion of all individuals remain undetectable during any single year. In the case of *Neotinea* (p. 99), for example, it proved to be difficult to distinguish dead plants from dormant ones.

Problems with annual plants

Annual plants differ from perennial plants in many ways with regard to how they should be monitored. Annuals may exhibit remarkable fluctuations in population size; when faced with unfavourable conditions they may spend long periods in seed banks; and they often inhabit disturbed habitats which may result in population structures following patch dynamics – with groups of individuals emerging on suitable sites which may be differently located every year. Their populations also often consist of a single cohort of plants, which means stage classification is not necessary.

Permanent plots are seldom useful in monitoring annual plants (see *Rhinanthus*, p. 48). Instead, the whole of the potential habitat on a site should be examined to record the number (and areas) of ecologically suitable patches, also distinguishing inhabited and empty patches. If resources allow, counting the number of individuals per inhabited patch may be useful in assessing fluctuations in population sizes. Size classification may also be beneficial where there are considerable variations in the sizes of individuals (and seed production).

Monitoring environmental parameters

Where population monitoring is concerned, any changes in the surrounding environment should also be recorded. There are very many environmental parameters which could be recorded. Making detailed vegetation analyses may be very laborious, however, and it is often hard to establish any clear connection between changes in the study population and changes in the surrounding vegetation. The monitoring of environmental parameters can be simplified in many ways. It could be worth concentrating on environmental parameters which are essential for regeneration (directly affecting flowering, seed production or seedling establishment). This of course involves detailed knowledge of the target plant's habitat requirements. Habitat descriptions should include measurements for at least the coverages of the ground and field layers (separating mosses, lichens, open ground, herbs, grasses and shrubs), the amount or coverage of litter, and the availability of light. In wooded habitats, a description of the tree layer is also important. Special attention should be paid to any habitat changes caused by human activity.

Taking photographs from fixed points is always an easy, reliable and fairly objective way to assess changes in the habitat.

In certain sensitive habitats like fens and springs, the act of monitoring may itself induce considerable changes in conditions. In fens, for example, the relative area of hummock-level vegetation may decrease, and the areas of flarks increase correspondingly, due to trampling. Trampling may also affect the monitored population itself, in both negative and positive ways. It may be difficult to completely avoid any damage to sensitive habitats, but this should certainly be taken into account when monitoring is planned. Replacing a large quadratic monitoring plot with a transect may considerably help to reduce the effects of trampling within a monitored site.

A comparison between Estonian and Finnish monitoring procedures

The monitoring practices differ considerably in these two countries. Systematic monitoring of threatened and protected plants started in Estonia already in 1994 as a part of National Environmental Monitoring program. The monitored species and sites were defined, and monitoring frequencies and uniform methods were detailly described. In the beginning, only the so called "plot monitoring method" was in use, but since 1999 a somewhat lighter "status monitoring method" was also applied to allow a larger number of populations to be monitored. At the moment, 603 sites of 153 vascular plant species are included in the monitoring program. The monitoring work is mainly done by professional botanists but a small group of competent volunteers are also involved. The results of monitoring are reported yearly. In addition, also more popular reports of the central results of biodiversity monitoring are being published (e.g. Klein (ed.) 2000: Eesti looduse mitmekesisuse riiklik seire. Keskkonnaministeeriumi Info- ja Tehnokeskus).

In Finland, a systematic monitoring program which would cover the whole country is not yet in use. Basically, all threatened vascular plant species (180 taxa) and their sites (several thousands) are a target of monitoring, but in practice only a small fraction of populations are monitored regularly. Monitoring methods have not been fixed, but by using a monitoring data sheet at least a minimum level of information from each population is being received. There is much variation in the quality and accuracy of monitoring data, varying from detailed demographic monitoring to brief descriptions of the condition of the site. To improve the monitoring data a guide for vascular plant monitoring was published in 1998. The monitoring work is done partly by professional biologists but voluntary expert botanists are in crucial role in collecting data. Data is being stored in the threatened species database of the environmental adiminstration, but no systematic data analysis or reporting is being done.

Appendix 1. Pulsatilla patens

1. Pulsatilla patens, 16. May 1997, Janakkala Finland (photo: Terhi Ryttäri)

2. Pulsatilla patens, 16. June 2000, Janakkala Finland (photo: Terhi Ryttäri)

3. Pulsatilla patens, 16. May 1997, Janakkala Finland (photo: Terhi Ryttäri)

4. *Pulsatilla patens*, 16. June 2000, Janakkala Finland (photo: Terhi Ryttäri)

Appendix 2. Rhinanthus rumelicus ssp. osiliensis

Rhinanthus rumelicus ssp. osiliensis, 23 September, 2003, Saaremaa Estonia (photo: Riho Västrik)

Appendix 3. Ligularia sibirica

1. Ligularia sibirica, 19. July 2000, Tagula Estonia (photo: Ülle Kukk)

2. Ligularia sibirica, 19. July 2000, Tagula Estonia (photo: Ülle Kukk)

Appendix 4. Agrimonia pilosa

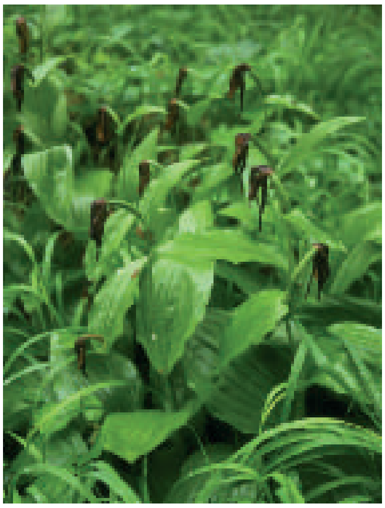
1. Agrimonia pilosa, 12. September 1989, Padasjoki Finland (photo: Eija Kemppainen)

2. Agrimonia pilosa, 7. July 1995, Padasjoki Finland (photo: Eija Kemppainen)

3. Agrimonia pilosa, 11. August 1996, Padasjoki Finland (photo: Terhi Ryttäri)

Appendix 5. Cypripedium calceolus

1. Cypripedium calceolus, 23. June 2003, Hyvinkää Finland (photo: Terhi Ryttäri)



2. Cypripedium calceolus, 26. June 2002, Hyvinkää Finland (photo: Terhi Ryttäri)

3. Cypripedium calceolus, 24. June 2002, Savonlinna Finland (photo: Terhi Ryttäri)

4. Cypripedium calceolus, 24. June 2002, Savonlinna Finland (photo: Terhi Ryttäri)

Appendix 6. Epipactis palustris

1. Epipactis palustris, 30. June 1998, Hiiumaa Estonia (photo: Terhi Ryttäri)

2. Epipactis palustris, 19. August 1998, Inkoo Finland (photo: Terhi Ryttäri)

3. Epipactis palustris, 5. August 1997, Tervola Finland (photo: Terhi Ryttäri)

Appendix 7. Epipactis atrorubens

1. Epipactis atrorubens, Kuusamo Finland (photo: Anne Jäkäläniemi)

2. Epipactis atrorubens, Kuusamo Finland (photo: Anne Jäkäläniemi)

3. Epipactis atrorubens, 3. July 1998, Hiiumaa Estonia (photo: Terhi Ryttäri)

4. Epipactis atrorubens, 3. July 1998, Hiiumaa Estonia (photo: Terhi Ryttäri)

Appendix 7. Epipactis atrorubens

5. Epipactis atrorubens, Kuusamo Finland (photo: Anne Jäkäläniemi)

Appendix 8. Neotenia

Neotenia ustulata, Estonia
(photo: Rainar Kurbel)

Documentation page

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Author(s)	Terhi Ryttäri, Ülle Kukk, Tiiu Kull, Anne Jäkäläniemi & Mari Reitalu (Eds.)	
Title of publication	Monitoring of threatened vascular plants in Estonia and Finland – methods and experiences	
Abstract	Population monitoring is an irreplaceable tool in assessing the need for conservation and management measures to help threatened species, and in evaluating the success of such measures. The monitoring of threatened species has recently become closely connected with national commitments under the EU Habitats Directive, and the concept of 'favourable conservation status'. The objectives of such monitoring may thus vary considerably. The geographical scale of monitoring may also vary, from site level to national or even international level. Monitoring work can consume a lot of resources, so it is extremely important that monitoring enables the most crucial questions to be answered. This report examines many important practical issues related to the population monitoring of threatened vascular plants. Eight example case-studies are examined in detail, so as to assess which aspects of the monitoring methods used in Finland and Estonia are most favourable, and in order to recommend how monitoring can be improved practically in the future. The issues discussed in the report include the importance of understanding the biology of the target species; the significance of the timing of population monitoring; the usefulness of permanently marking plots and individuals; the application of size/stage classifications; the usefulness of measuring various morphological characteristics; the interpretation of short-term and long-term results; and how environmental parameters should be recorded.	
Keywords	vascular plants, monitoring, directive 92/43/EEC, favourable conservation status, conservation, population biology, Agrimonia pilosa, Ligularia sibirica, Cypripedium calceolus, Pulsatilla patens, Epipactis atrorubens, Epipactis palustris, Neotenia ustulata, Rhinanthus osiliensis	
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Julkaisija	Suomen ympäristökeskus	Julkaisuaika Joulukuu 2003
Tekijä(t)	Terhi Ryttäri, Ülle Kukk, Tiiu Kull, Anne Jäkäläniemi & Mari Reitalu (Eds.)	
Julkaisun nimi	Monitoring of threatened vascular plants in Estonia and Finland – methods and experiences Uhanalaisten putkilokasvien seuranta Virossa ja Suomessa – menetelmiä ja kokemuksia	
Tiivistelmä	Uhanalaisten lajien populaatioiden seurantaa tarvitaan lajien suojelu- ja hoitotarvetta sekä tehtyjen toimenpiteiden onnistumista arvioitaessa. Lajiston ja yksittäisten lajien suojelutason kehittymisen seurantaan velvoittaa myös EU:n luontodirektiivi. Seurannan tavoitteet ovat siten hyvin moninaiset ja maantieteellinen mittakaava voi vaihdella yksittäisistä esiintymistä kansalliselle ja kansainväliselle tasolle asti. Seurantatyö vaatii paljon voimavaroja, joten on tärkeää suunnitella se niin, että seurannoista saadut tulokset myös vastaavat esitettyihin kysymyksiin. Tässä raportissa käsitellään uhanalaisten putkilokasvien populaatioiden seurantaa hyvin käytännönläheisestä näkökulmasta. Kahdeksan esimerkkitapauksen avulla arvioidaan käytettyjen seurantamenetelmien ja tehtyjen mittausten hyviä ja huonoja puolia ja pohditaan miten seurantaa kannattaisi jatkossa tehdä. Raportissa tarkastellaan muun muassa seuraavia seurannassa huomioon otettavia asioita: kohdelajien biologian ymmärtämisen tärkeys, seuranta-ajankohdan merkitys tuloksille, pysyvästi merkittyjen seuranta-alojen ja yksilöiden käyttökelpoisuus, kasvien koko/elämävaiheluokittelun merkitys, morfologisten mittausten merkitys, lyhyen- ja pitkän aikavälin tulosten tulkinta sekä erilaisten ympäristömuuttujien kirjaamisen merkitys.	
Asiasanat	putkilokasvit, seuranta, luontodirektiivi 92/43/EEC, suotuisa suojelutaso, luonnonsuojelu, populaatiobiologia, Agrimonia pilosa, Ligularia sibirica, Cypripedium calceolus, Pulsatilla patens, Epipactis atrorubens, Epipactis palustris, Neotenia ustulata, Rhinanthus osiliensis	
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Autor(id)	Terhi Ryttäri, Ülle Kukk, Tiiu Kull, Anne Jäkäläniemi & Mari Reitalu (toim.)	
Väljaande nimetus	Monitoring of threatened vascular plants in Estonia and Finland – methods and experiences Ohustatud soontaimede seire Eestis ja Soomes – meetodid ja kogemused	

Resümee

Populatsioonide seire on asendamatu vahend ohustatud liikide kaitse ja kasvukohtade majandamise meetmete või nende edukuse hindamisel. Ohustatud liikide seire on viimasel ajal tihedas seoses ka EL loodusdirektiiviga seotud riiklike kohustustega ja nn. soodsa kaitseseisundiga. Seire eesmärgid võivad siiski oluliselt varieeruda. Seire geograafiline skaala võib varieeruda leiukoha tasemelt riikliku või isegi rahvusvahelise tasemeni. Seiretöö nõuab palju ressursse, seetõttu on eriti tähtis, et seire annaks vastuse kõige olulisematele küsimustele.

Käesolev publikatsioon käsitleb ohustatud soontaimeliikide populatsioonide seire praktilisi aspekte. Kaheksa näidet (seire uuringut) on detailselt läbi töötatud, et saaks hinnata, millised kasutatud seiremeetodite aspektid on kõige eelistatumad, ja võiks teha soovitusi praktilise seire parandamiseks tuilevikus. Arutatakse näiteks näidisliikide bioloogia tundmise tähtsust, populatsionide seire õiget ajastamist, püsiruutude ja märgitud isendite kasutamise vajadust, suuruse ja arenguastmete klassifitseerimist, mitmete morfoloogiliste karakteristikute mõõtmise otstarbekust, interpreteeritakse lühi- ja pikaajaliste mõõtmiste tulemusi ja keskkonnaparameetrite registreerimist.

Võtmesõnad	vascular plants, monitoring, directive 92/43/EEC, favourable conservation status, conservation, population biology, Agrimonia pilosa, Ligularia sibirica, Cypripedium calceolus, Pulsatilla patens, Epipactis atrorubens, Epipactis palustris, Neotenia ustulata, Rhinanthus osiliensis	
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Publikationens titel	Monitoring of threatened vascular plants in Estonia and Finland – methods and experiences Publikationens titel: Övervakning av hotade kärlväxter i Estland och Finland – erfarenheter och metoder	
Sammandrag	Övervakning av hotade arters populationer behövs när man bedömer behovet av arters skydd och skötsel samt när man bedömer hur utförda åtgärder lyckats. Även EU:s habitatdirektiv förpliktar att man följer med utvecklingen av skyddsnivån för artsammansättningar och enskilda arterna. Målen för övervakningen är många. Geografiskt varierar perspektivet från artens enskilda lokal till en riksomfattande eller internationella nivå. Uppföljning kräver rikligt med resurser, och därför är det viktigt att den planeras så att resultaten verkligen svarar på de ställda frågorna. I denna rapport behandlas uppföljningen av hotade kärlväxtpopulationer ur ett rätt så praktiskt perspektiv. Med hjälp av åtta exempel bedöms nack- och fördelarna med de uppföljningsmetoder man använt och de mätningar man gjort. Sedan begrundas hur uppföljningen borde skötas i fortsättningen. I rapporten granskas bland annat följande frågor som bör beaktas vid övervakning: vikten av att känna till respektive arters biologi; uppföljningstidpunktens inverkan på resultaten; permanent märkta ytors och individers användbarhet; betydelsen av växternas storleks/livsfas-klassificering; betydelsen av morfologiska mätningar; tolkningen av resultaten för såväl längre som kortare perioder samt betydelsen av att olika miljövariabler registreras.	
Nyckelord	kärlväxter, övervakning, habitatdirektiv 92/43EEG, gynnsam bevarandestatus, naturskydd, populationsbiologi, Agrimonia pilosa, Ligularia sibirica, Cypripedium calceolus, Pulsatilla patens, Epipactis atrorubens, Epipactis palustris, Neotenia ustulata, Rhinanthus osiliensis	
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Monitoring of threatened vascular plants in Estonia and Finland – methods and experiences

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The authors hope that this report will make a useful contribution towards improvements in the practicality and cost-efficiency of monitoring.

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