

Edited by Iiro Ikonen and Eija Hagelberg



Read Up on Reed!

Cover photo: The chattering song of the Great Reed Warbler may be heard in the finest reed bed areas. Photo: Antti Below.

Back cover photo: Making a Green Art installation in March 2006, in Halikko, Southwest Finland. Photo: Jarmo Markkanen.

Lay out: Ulriikka Lipasti

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Part I

Reed as It is





Reed harvesting in focus in Halikonlahti Bay, Halikko. March 2006. Photo Eija Hagelberg.



Welcome to the Reed Coast!

Reed is the main character in Estonian and Southern Finnish coastal areas both onshore and offshore. The species is known the world over. Reed has gradually encroached upon our coastline and its expansion has been accelerated by human activities: eutrophication, climate change and the cessation of coastal meadow management.

The characteristics of reed and reed beds and their significance for water quality are described in the first and second chapters of this book: *Reed as it is* and *Pure Reed*.

Reed can be seen as an invasive problem species. We can lose our familiar landscape and our recreation areas because the coastline has become overgrown. Reed beds host several species but at the same time, the amount of coastal meadow and the species that live on it have drastically declined. The third chapter, *Voices in the Reed Bed* describes the biodiversity of reed beds and coastal meadows. A glossary including bird and vascular plant names in Estonian, Finnish and Swedish can be found on the last pages.

Reed beds can also be seen as a possible source of income. Reed can be used as bioenergy and as construction material. The Interreg IIIA project "*Reed Strategy in Finland and Estonia*" has developed and tested some solutions suitable for our coastal areas. The chapter *Touch and Thatch* describes the history of reed and its use in art and handicrafts and thatching (roofing). *Burning to Know* reveals the characteristics of reed and the possibilities of utilising reed for bioenergy.

The balance between the preservation, utilisation and management of coastal areas is a fundamental question and is one that is related to the creation of strategy pilots in Finland and Estonia. We shall see an example of a strategy map of the town of Salo in the chapter *Gathering in Reed*.

Our Finnish-Estonian "reed team" felt that this multi- and interdisciplinary project fits well in the Interreg IIIA programme frame. This kind of approach was important because specialists tend to discuss matters in circles of their own and in this case it was especially fruitful to have input from experts in other fields. In this way, information and knowledge was shared and compiled in numerous meetings. The network created by this project is of vital importance to its success.

There are regionally tailored solutions to the question of how to make a profit from reed while still honouring other values such as biodiversity, recreation and water purity. Sustainable and ecologically sound solutions such as reed construction will certainly take deeper root in the future. After a long working day it is heavenly to rest in a peaceful thatched house and to blend in with the harmony of nature. The project has formed the basis for several new approaches and projects in the Baltic Sea Region.

The winds of change are blowing.

Project Coordinator

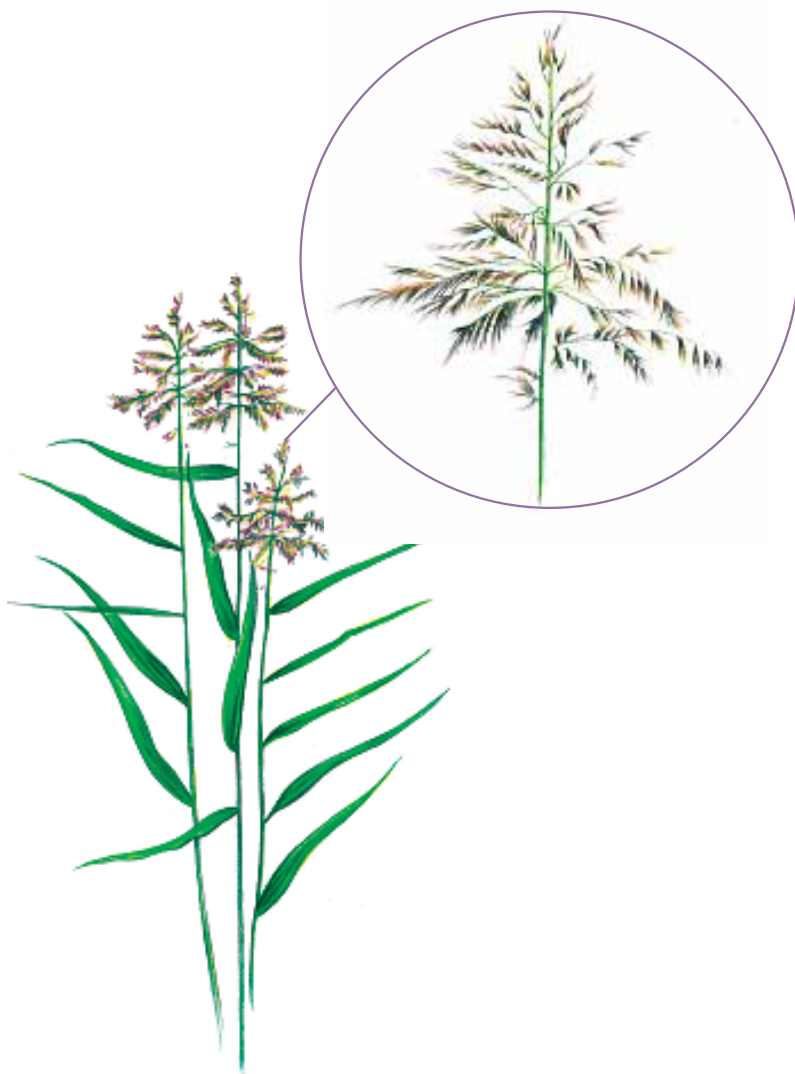
Iiro Ikonen

26 July 2007

The Reed itself - *Phragmites australis*

(Cav.) Trin. ex Steud.: taxonomy, morphology, biology, ecology, problems

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Morphologically the Common Reed (*Phragmites australis*) is a perennial hydrophyte-geophyte with usually very high shoots (up to 4 m, seldom even 7 m). The height of the shoots depends on air and water temperature, humidity, the content of nutrients and management. The Common Reed usually forms dense stands and approximately 200 shoots of 1 m² can be found, which leaves are helomorphic, 1-3 cm, seldom 5 cm wide. These plants have an extensive creeping rhizome system (rhizomes 1-3 cm thick) + dense fibrous roots and vesicular-arbuscular mycorrhiza is a characteristic feature of its roots. The florescence is a dense panicle up to 30 cm (sometimes 50 cm) long. The duration of flowering lasts up to 3 months. *Phragmites australis* is crosspollinated by wind, with the weight of seeds comprising 0,1 g, which are not only dispersed by wind, but also by birds, water and humans. The seedbank is short-aged, transient (less than 1 year). Reproduction by seeds, however, is poor and the reed grows mainly vegetatively by rhizomes (Haslam 1972). On the other hand seeds were dispersed by humans in the IJsselmeer area in Netherlands in 1950's, resulting within 3 years in monotonous reed stands. (Rodewald-Rudescu 1974).

In plant communities the Common Reed is highly competitive: according to Grime's life-strategy system, it is a competitor/stress tolerator (<http://ufz.de/biolflor>). The main competitive advantages of reeds are as follows:

- 1) any lateral bud can develop into a horizontal or vertical rhizome;
- 2) tall and dense reed stands prevent light reaching to ground level and suppress the growth of other species;
- 3) the litter mat covers the ground, preventing other species from germinating and growing there;
- 4) a dense root and rhizome system creates very difficult root competition conditions for other species in the soil.

Hence, the reed excludes smaller species as a result of competition and modifying the environmental ground (much of

Common Reed, *Phragmites australis*. Picture: Mimmi Vuoristo 2007.



Common Reed grows fast: on 19th June 2006, which was a mowing day in Halikko, Southwest Finland, this reed was already two metres high. Photo: Eija Hagelberg.

litter) and above-ground (high shoots) level (Minchinton et al. 2006). These factors decrease the competitive ability of the Common Reed:

- 1) shading by other plant species;
- 2) severe frosts in winter;
- 3) serious drought during the vegetative period;
- 4) strong wave and ice activity;
- 5) grazing and mowing;
- 6) burning.

The soils where the Common Reed grows are very variable. However, it prefers nutrient-rich habitats with organic matter content up to 97%. The pH of the soil can vary between 3.6-8.6, but in most cases it is 5.5-7.5. The shoot height is

largely controlled by a high content of phosphorus, potassium and calcium ions in the soil. The Common Reed is able to grow in a very wide array of habitats: fens, shallow lakes, salt marshes, open aquatic communities. In classifying plant communities, the following community types are most frequently mentioned: *Parvocaricetum*, *Magnocaricetum*, *Molinietum*, *Halo-Phragmitetum australis* community, *Phragmites-Schoenoplectus-Typha latifolia* community, *Phragmites-Schoenoplectus* community (Haslam 1972).

In recent decades, the Common Reed has become a serious conservation problem because it has spread into ecologically valuable habitats and as a result of being a strong competitor, it has eliminated most other species. This phenomenon has

The Common Reed, in latin *Phragmites australis* (Cav.) Trin. ex Steud. (previously also *Phragmites communis* Trin. and *Arundo phragmites* L.), belongs taxonomically to the family *Poaceae* (R.Br.) Barnhart. The genus *Phragmites* comprises nowadays 7 species :

1) *Phragmites australis* (Cav.) Trin. ex Steud., which is divided into three subspecies:

- a) *Phragmites australis* ssp. *Australis*, growing in the temperate regions of both hemispheres;
 - b) *Phragmites australis* ssp. *altissimus* (Benth.) Clayton (the plant is taller and has a larger panicle than ssp. *australis*), growing in the Mediterranean area, in the Middle East, North Africa;
 - c) *Phragmites australis* ssp. *americanus* Saltonstall, P.M. Peterson & Soreng, growing in North America
- 2) *Phragmites vallatoria* (Plunk. ex L.) Veldk [previously *P. karka* (Retz.) Trin. ex Steud.], growing in tropical Asia, Polynesia, Australia and tropical Africa;
 - 3) *Phragmites mauritianus* Kunth, growing in tropical Africa;
 - 4) *Phragmites japonicus* Steud., growing in Eastern China, Japan, Russian Far East;
 - 5) *Phragmites frutescens* H. Scholtz, growing in Greece and Turkey;
 - 6) *Phragmites dioica* Hackel ex Conert, sparse information, found in Argentina and Uruguay;
 - 7) *Phragmites berlandieri* E. Fourn, sparse information, found in North America (Lambertini et al. 2006).

There is a great variety in the chromosome numbers of different species and subspecies (euploidy levels 3x, 4x, 6x, 7x, 8x, 10x, 11x and 12x) considered to be the result of irregularities in meiosis and/or somatic mitosis. In Europe tetraploids predominate. The responses of the Common Reed to climate, hydrology and salt have a genetic basis (Lambertini et al. 2006).



On shallow seashores reed has spread all along the coastline. The Archipelago Sea, Finland. October 2006. Photo: Eija Hagelberg.

resulted in the rapid decrease in biodiversity. The main reasons for the expansion of the Common Reed are as follows:

- 1) decreased management activities, mainly grazing and mowing;
- 2) climatic changes: comparatively mild winters without permanent ice on the sea (ice destroys the reed rhizomes);
- 3) increased mean t° favours the growth of reed.

Some years ago, one more idea emerged helping to explain the rapid invasion of the Common Reed. The comparison of genotypes of historical (using herbarium collections) and present-day specimens of reed demonstrate that these are genetically different and probably have a different ability to expand, too (Saltonstall 2002). A good description about the physiology, biology, ecology and response to manipulations of the Common Reed is given e.g. by Mal and Narine (2004).

References

- Haslam, S.M. 1972. *Phragmites communis* Trin. Biological Flora of the British Isles. – J. of Ecol.: 60: 585-610.
- Lambertini, C., Gustafsson, M.H.G., Frydenberg, L., Lissner, J., Speranza, M. & Brix, H. 2006. A phylogeographic study of the cosmopolitan genus *Phragmites* (*Poaceae*) based on AFLPs. – Plant Syst. and Evol. 258: 161-182.
- Mal, T.K. & Narine, L. 2004. The biology of Canadian weeds. 129. *Phragmites australis* (Cav.) Trin. ex Steud. – Can. J. Plant Sci. 84: 365-396.
- Minchinton, T.E., Simpson, J.C. & Bertness, M.D. 2006. Mechanisms of exclusion of native coastal marsh plants by an invasive grass. – J. of Ecol. 94: 342-354.
- Rodewald-Rudescu, L. 1974. Das Schilfrohr. Die Binnengewässer Band XXVII. Stuttgart.
- Saltonstall, K. 2002. Cryptic invasion by a non-native genotype of the Common Reed, *Phragmites australis*, into North America. – Proc. of the Nat. Acad. of Sci. of the USA 99: 2445-2449.
- The database BioFlor, UFZ - Centre for Environmental Research, the Department of Community Ecology, Germany.
<http://www.ufz.de/bioflor/index.jsp> [ref. 10th April 2007].

Reed resource mapping in Finland and Estonia

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In spite of being a prominent part of the coastal ecosystem in southern Finland and Estonia, there has been a lack of accurate information on the spatial distribution of reed (*Phragmites australis*), or at least studies concerning the topic have been relatively small-scale and scattered. Reed is a challenging target to map since it grows on the interface between marine and terrestrial environments. In addition, its appearance and existence markedly depend on the acquisition date, with reed stands often being characterized by unclear transitional zones to e.g. meadows. Owing to these reasons as well as to a limited interest in producing accurate reed maps, the existing information regarding reed-growing areas prior to this resource mapping was found to be insufficient and not up-to-date to be suitable for specific, reed-oriented purposes. That is why it was found essential to conduct this analysis – to ascertain more accurately where reed actually grows.

The resource mapping was carried out over a comparatively large research area (coastal areas of southern Finland and NE Estonia; Fig 1.), and the time span allocated to complete the study was three months (Feb-Apr 2006). When mapping vegetation patterns, such as reed-growing areas, a suitable balance between the scale and scope has also to be decided upon, the result of which, being that the decision must correspond to the workload and the costs available to be utilised. For that reason, the analysis was conducted by interpreting satellite images enabling the processing of a large area in a comparatively short time. Air photos would have given far more detailed results, but neither the schedule nor financial resources supported their use.

Prior to performing the analysis for the whole area, a small pilot study was conducted in order to assess the suitability

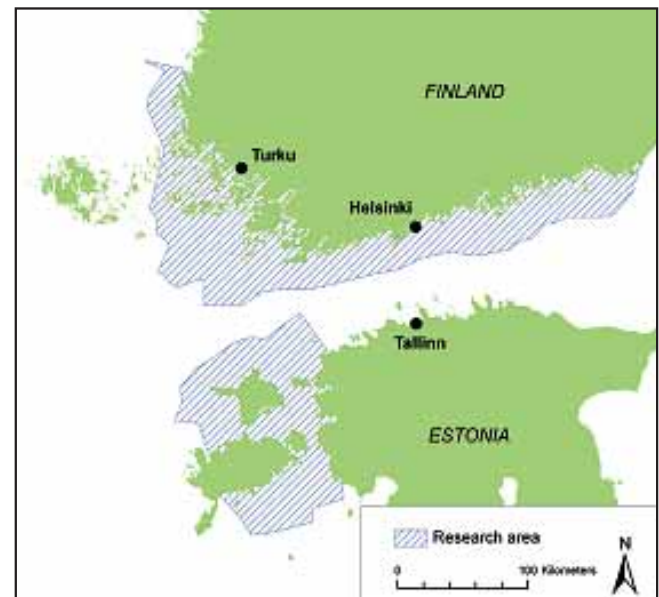


Fig. 1. The research area.

of satellite imagery for reed resource mapping, as well as to provide a rough estimate on the accuracy of the results. A small area near the city of Turku, SW Finland was selected for the testing area because of the optimal availability of satellite images and air photos for this purpose. The satellite images selected were three separate Landsat TM/ETM+ frames acquired on June 1984, July 1992 and August 1997. These Landsat satellites have a spatial resolution of 30 m (i.e. the image pixel size; the smallest detectable unit) and they contain 7 channels, each of which is capable of detecting

a different wavelength area of the spectrum (or 8; ETM+ satellites possess an extra panchromatic channel). A Landsat frame covers an area of 185 x 185 km with a 16-day acquisition cycle detection frequency of the same area. However, the usability of a single frame depends primarily on the weather conditions. All of these three analysed images covered exactly the same area, but because they represented different months of acquisition, they made it possible to assess whether there were differences between early and late summer dates regarding reed-growing areas. Wintertime images were not chosen to be utilized because the availability of winter images of good and uniform quality would be fairly difficult to obtain for the whole study area as a result of highly varying snow/ice conditions. One image acquired by ASTER satellite was also investigated, but despite its better spatial resolution (15 m), it was not found to be superior to Landsat images, as ASTER images are limited because of poorer spectral resolution (number of channels). Moreover, analysing the whole research area by using them would have been far more expensive and laborious compared to Landsat frames. All the computer-aided analyses needed for the pilot study, as well as for the whole resource mapping study, were conducted in the Laboratory of Computer Cartography at the Department of Geography, University of Turku, Finland, by using ERDAS Imagine 8.7 and ArcGIS 9.1 programs.

The pilot study involved testing several methods developed for satellite image processing. These methods included unsupervised classification (*Isodata*-clustering), supervised classification, vegetation indices (*IR/R* and *NDVI*) and other spectral enhancement procedures (principal component analysis and *Tasseled cap* –transformation). In conclusion, the best results were gained by carefully supervised classification – a method that requires the definition of small training areas for each spectrally differing land cover class. Based on the information provided by the user, the classification for the whole image area is completed by the computer program. Some further processing steps were found necessary prior to introducing the final area of reed-growing areas in polygon format: only those areas classified to be reed in contact with the shoreline should be kept (this will delete all inland “reed” areas that are more likely to be erroneously classified and do not belong to the scope of this study). The remaining reed-classified pixels should be filtered by using 3x3 *majority*-functions (this will reduce noise, *i.e.* fill small holes inside larger reed patches and delete isolated reed pixels). After converting the raster data set into polygon format, border lines should be slightly smoothed

out to achieve a realistic result. Reed patches appear to extend their area significantly during the late summer dates. However, the expansion of reed areas in general between the years 1984–1997 may have affected the results. The analysis concluded that late summer images should be used in the analysis. Furthermore, an accuracy assessment of the resulting reed area delineations was performed by comparing aerial image interpretation. Two true-colour air photos from the year 1998 were used, acquired at an altitude of 2350 m. It was found that satellite image interpretation is by no means a flawless method. Nevertheless, it still is capable of producing fairly accurate results by recognizing approximately 70 % of all reed-growing areas. This degree of accuracy was judged to be sufficient to be used in reed resource mapping.

The mapping was conducted for the whole study area by using the methodology found most suitable during the pilot study. The satellite images chosen for this task were Landsat TM/ETM+ -images, which fulfilled the conditions set for the acquisition year (less than 10 years old), month (end of July or August) and weather (as few clouds as possible), and for the price – the most expensive categories of Landsat images were not affordable. The study area was covered by using four separate image frames acquired between the years 1997–2002. Two additional images were used to cover a few minor clouds present in the main images. Thermal and panchromatic channels were removed from the images, and they were georeferenced and rectified at a maximum error of 15 meters, with water areas being masked away. After preprocessing procedures, all satellite images were classified by using the supervised approach (*maximum likelihood* classification). The classification results of separate images, especially of the adjacent frames, were constructed to be as similar as possible before converting them into polygons and combining the outcome into a single data set. All polygons outside the shore zone were deleted, and results were checked with apparently misclassified polygons being removed. Finally borderlines were evened out.

While the results indicated that reed is quite common in the coastal zone of southern Finland (Fig. 2.), the extent of reed patches vary markedly between different regions. The largest areas covered by reed are located in the sheltered bays of middle and southern Varsinais-Suomi province as well as in eastern Uusimaa and Kymenlaakso provinces. Reed-growing areas are most extensive on the mainland shores – patches grow smaller and belts narrower in the more unsheltered archipelago areas. The total reed coverage in the Finnish study area was 28 000 ha, consisting of approximately 25 000 separate polygons. On



the municipal level, the largest reed-growing areas were found in Pernaja (2125 ha), Porvoo (2124 ha) and Tammisaari (1742 ha).

In the Estonian study area, reed areas are not as evenly located as in Finland (Fig. 3.) – some shores are totally lacking reed, but a few patches, especially in Matsalu bay, cover considerably large areas. The majority of other noteworthy reed areas are located on the mainland shores and on the sheltered coastline of Saaremaa island. By contrast, the areas of higher wind exposure are almost reedless. Satellite image interpretation was found to be more difficult in Estonia, compared with Finland because of a larger area of meadows and other reed-like vegetation (reed-like regarding spectral signals received by satellite). The total coverage of reed-growing areas in the Estonian study area was 17 000 ha, consisting of approximately 4400 separate reed polygons. On the municipal level, Lihula (2553 ha), Ridala (1492 ha) and Kärla (1410 ha) were most featured by reed-growing areas, the two first-mentioned of which are situated on Matsalu bay and the last one on the southern coast of Saaremaa island.

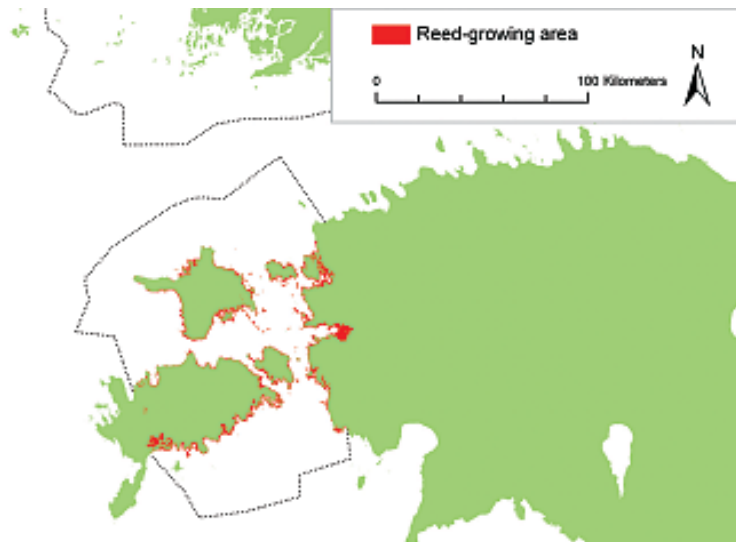


Fig. 3. Reed patches in the Estonian study area.

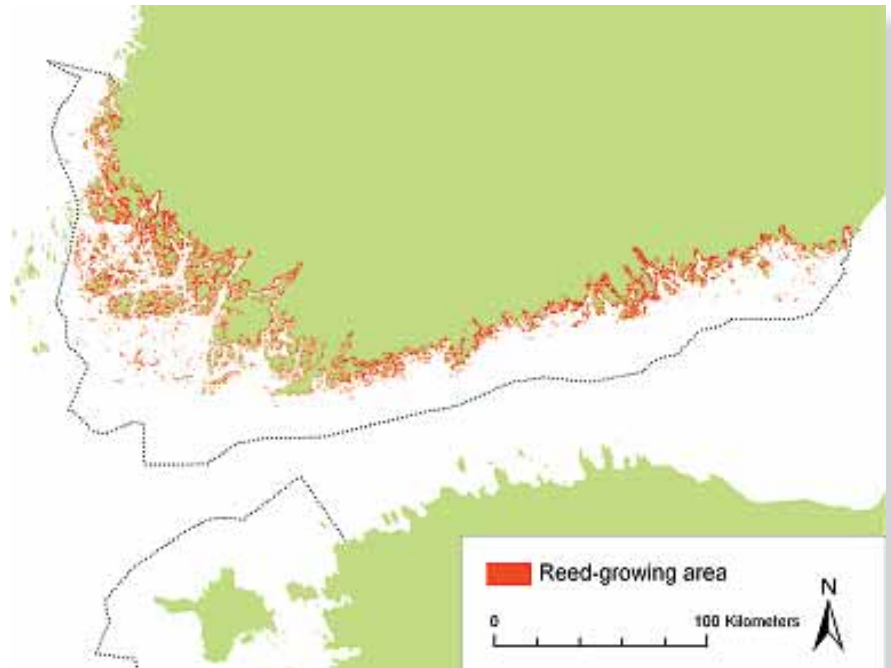


Fig. 2. Reed patches in the Finnish study area.

The accuracy of satellite-based mapping is dependent on the methodology used and the experience of the interpreter. The results, however, may always be seen as slightly subjective. Nonetheless, the results attained in the reed resource mapping were regarded as fairly accurate, compared with the workload. Still, because they lack a comprehensive accuracy assessment and the resolution of the satellite images restricts the detection of smaller targets, they should for the most part be interpreted as trend indicating results. Other sources of errors also include possible deficiencies in geometric accuracy, “mixed pixels” or pixels containing more than one land cover type, fallacious classification training areas and spectral similarities of reed-growing areas cover classes. However, the purpose of the mapping was found to be sufficiently realized – the study offers a good general-level estimate of the presence of reed-growing areas on the coastal zones of southern Finland and NW Estonia, providing a good starting point for further reed-related activities.

The methodology of mapping reeds from interpreting Landsat satellite images has been developed and tested in Finland. Estonian coastal conditions are different with different bedrock, relief gradients and coastal morphology. Thus, reeds are subject to different ecological conditions. To control how the efficacy of the method in Estonian reeds, Finnish mapping results were compared with the Estonian reed map from Saaremaa Island. Both the area of reed beds and the spatial placement of reed polygons are compared.

The Saaremaa reed map (Fig. 4.) is made by correcting Finnish data by analyzing true color aerial photos, as well as by examining the Estonian basic map (1:10 000), Corine land cover data, coastal databases and using expert knowledge.

The results (Table 1.) show that the average reed area error amounts to 14.9%, which is in accordance with the preferred 70% probability. The maximum error is up to 50% in Mustjala parish. The results are not as accurate, when or after comparing the common part of corrected and not corrected reed polygons. It seems that polygons derived from satellite images and detailed reed polygons have a common spatial part of less than 70%, meaning 30% of calculated reed areas don't actually have real reed cover. In Leisi parish, the calculated reeds cover spatially only 37% of the reeds (having an area error of only 13%). It seems that because reeds have spread to the narrow area along the coastline, the spatial error of ~25 m can "relocate" reeds to areas devoid of reeds.

The results of this analysis show that the methodology of mapping reeds from a satellite works in Estonian coastal areas on the county level. On the parish level, the probability of error can be too significant to use this data in the actual planning process. Because reeds usually have a specifically stretched shape, they are very sensitive to spatial errors. The preprocessing of satellite images must be very carefully performed in order to provide the reed map with spatial accuracy.

References:

Pitkänen, T. (2006). Missä ruokoa kasvaa [Where reed grows?]. Turun ammattikorkeakoulu, Turku, Finland. Printed format in series Puheenvuoroja, vol. 29. Available also in internet: ruoko.fi/julkaisut [ref. 15th March 2007].

Parish	Reed bed area (satellite image interpretation)	Corrected reed bed area	error	Common part
	ha	ha	%	%
Laimjala	476	318	33,1	63,7
Pöide	744	696	6,5	58,8
Muhu	916	854	6,8	60,3
Orissaare	277	274	1,0	64,8
Kaarma	1307	1344	2,8	65,0
Kärla	1309	1539	17,6	71,8
Kuressaare linn	120	98	18,9	71,5
Valjala	380	432	13,7	50,5
Pihitla	535	518	3,2	60,5
Mustjala	179	94	47,3	54,4
Leisi	132	115	13,1	37,0
Kokku/Total	6375	6281	1,5	63,3

Table 1.



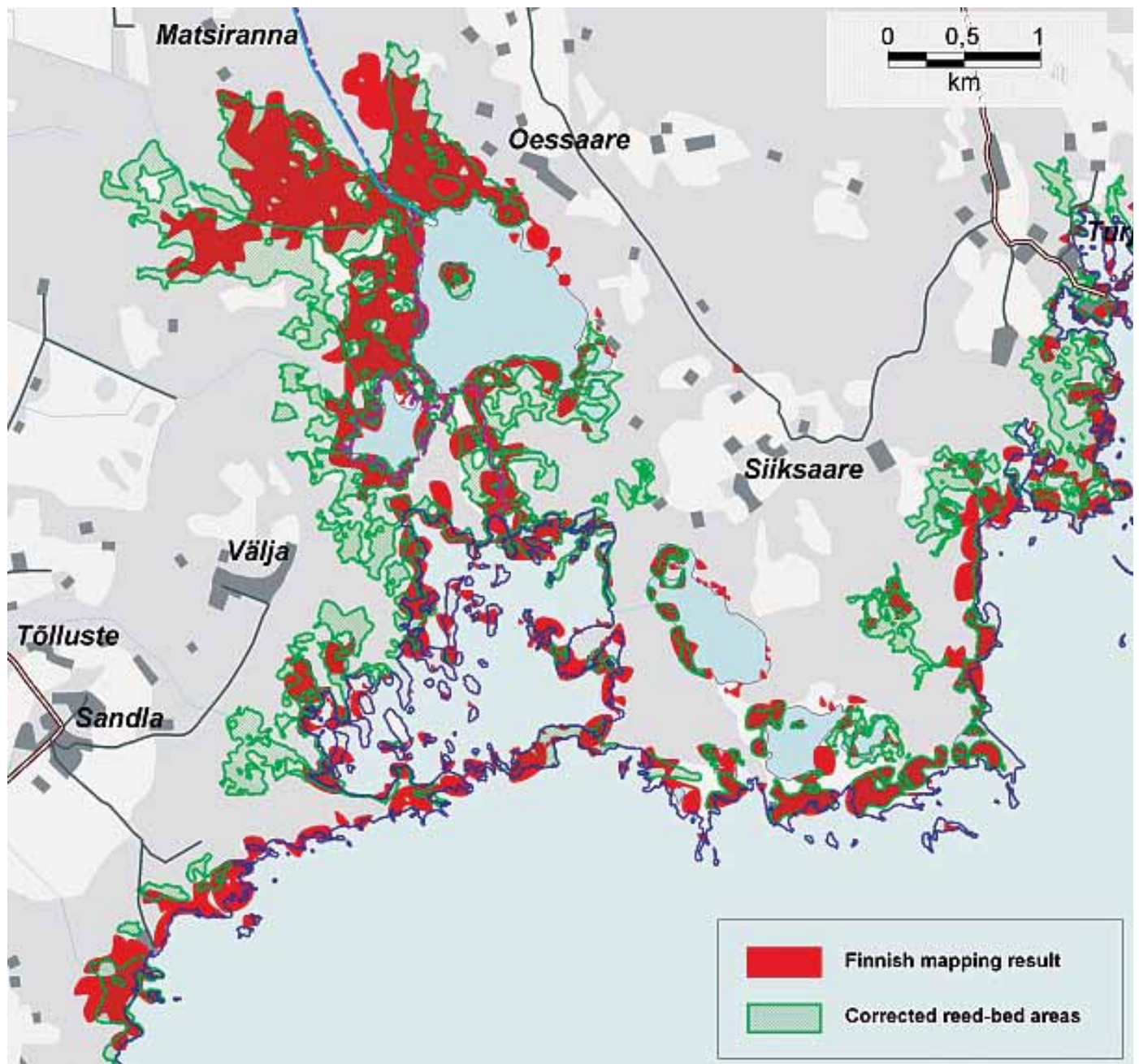


Fig.4. An example of the comparison between the first study, which was Finnish, and the second study, which was Estonian. Map: Tambet Kikas.



Mapping reed beds in Matsalu, Estonia. Photo: Kaja Lotman.



Reed is not uniform

– Classification of reed beds and reed biomass and quality mapping

Case study in Turku and Salo, Southwest Finland

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This work aimed to produce vegetation classification for coastal wetlands in two pilot sites in Southwest Finland. In this classification reed beds were subdivided into several sub-classes based on specific properties that are generally related to the particular stage of reed bed succession. The study employed an interpretation of the colour infrared photographs and field surveys carried out during the summer 2006. These GIS-based vegetation maps were then combined with the results of dry reed biomass and thatch quality mapping. Combining a vegetation map and reed quality measurements into one database enables an overall assessment of reed beds and can serve as a starting point for planning of the management activities. The article is focusing mostly on the description of the methodology used in this work.

Classification approach

Planning of conservation and utilization activities within reed beds requires knowledge on their location, extent and quality. To assess their potential biodiversity value or usefulness for bioenergy and construction purposes, these coastal wetlands should be classified according to their properties. There is a challenge, however, to find a uniform classification approach that can be applied to different geographical locations. This is because reed beds vary from place to place due to a number of factors, including climate, topography, soil properties and management history of the site.

While all reed beds are typically dominated by monotonous stands of *Phragmites australis*, they differ in many ways. They vary in age, structure, water and litter level, and presence and abundance of other vegetation. Stems of reed may be different in height, density and thickness. These properties are likely related to the gradual stages of succession in the coastal wetland and may serve as a basis to classify reed beds into several types.

As known, an unmanaged reed bed presents a transitional

stage of natural succession from young reed that recently colonised areas of open water to dry land. Becoming older, reed beds accumulate litter and dead vegetation on the ground level. As a result, a litter layer rises and reed bed becomes dryer, allowing other plant species, including shrubs and trees, to colonise these habitats. Different reed bed classes represent different habitats that vary in the species they can support. Those reed beds standing in water during the summer often attract birds and invertebrates but have little botanical interest. In contrast, reed beds with water levels at or below the surface during the summer contain richer plant species composition.

The study followed the vegetation classification schema of Oesch (Oesch 1994), according to which reed beds can be divided into six sub-classes, ranging from dry reed bed that contains a large amount of other vegetation (class I) to pure stands of reed growing in water. The classification of reed beds is based on the bed's structure, water and litter level, and presence and amount of other vegetation (see Appendix 1 for classes' characteristics). Due to the water level and soil properties, ground in reed bed can be muddy, boggy or rather dry; other vegetation may occur vigorously and be predominant or be absent. Each reed bed class can also be characterised by the typically associated plant species. Employing this classification at our study sites, one more reed bed sub-class was added. Having the same characteristics as a *VI reed bed class*, it differs from it structurally, presenting a mosaic of water openings and patches of dense reed stands. This sub-class, hence, has been named as a *VI mosaic type* of reed beds. Due to the structure, such reed bed seems to be an important habitat for numerous bird species.

Study areas

Two coastal wetlands, both represented brackish water areas in different part of the Southwest Finland, were used in this

study. One is situated along the Halikonlahti Bay, Salo town, in a part of the Salo region, which is located 50 kilometres east of Turku and 100 kilometres west of Helsinki. The whole area of reed beds along the Halikonlahti Bay is more than 80 ha. Water of the bay is nutrient-rich due to the runoff from the surrounding agricultural lands and naturally slow water-exchange rates. Extensive reed beds there offer shelter for numerous migratory birds and nesting species. The second site is located on the island of Hirvensalo, which is a part of the city of Turku and situated in the front of the Turku harbour. The whole area of the island is 1280 ha, with reed beds covering about 95 ha. Part of the area, Friskalanlahti, is belong to the Natura 2000 Network

Vegetation classification

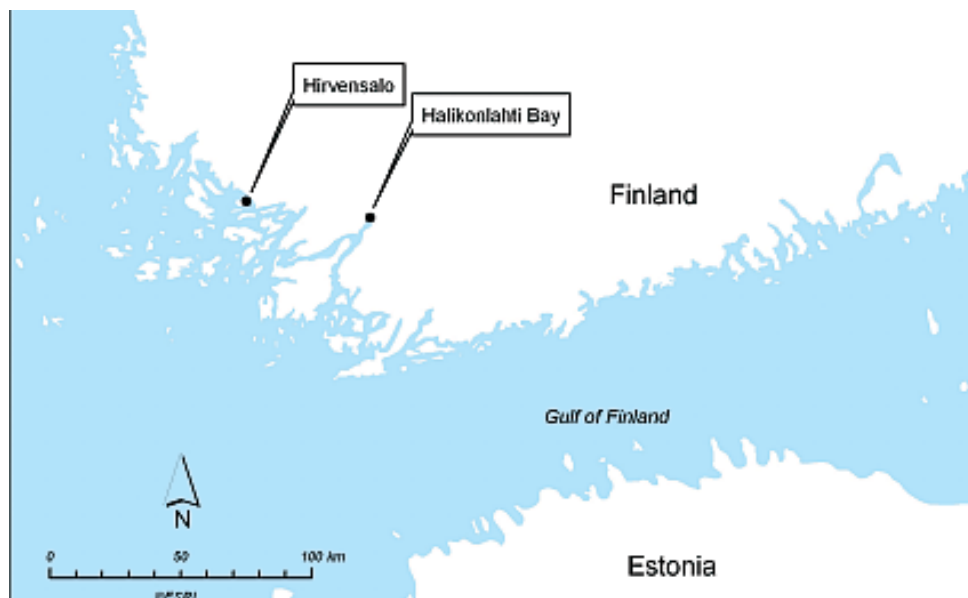
Preliminary vegetation maps were based on an interpretation of the colour infrared aerial photos having a high spatial resolution (one pixel covers area of 0.2 m 0.2 m), captured in early autumn. The images were interpreted to delineate different vegetation patches. Separation of reed beds from other vegetation types in colour-infrared photos was possible due to the differences in colour shadows varying from light green to intensive red. The density of the vegetation can also be seen in the photographs. At some sites one can even recognise height

of reed stands based on their shadows. The interpretation of the vegetation types was also supported by the digital Topographic Database, provided by the National Land Survey of Finland. This database contains, amongst others, polygons of floodplains and muddy areas. The polygons represented different vegetation types were drawn up on-screen in ArcGIS. Unclear boundaries between patches were checked in the field, employing the global position system (GPS). The field surveys were conducted in the summer of 2006. Because the study areas were relatively small, it was possible to observe most of them. In the field, the vegetation type of the patch, the site properties, such as bottom condition and water level, and the plant species found with in were recorded in the data sheets and then inputted into the ArcGIS database.

Reed quality and biomass mapping

Mapping of reed quality and biomass was carried in spring 2006. Field survey and location of the sample points were planned based on the maps derived from the satellite imagery and air photos.

In the field, properties of reed stands of each sample site were first evaluated visually and then measured. Three to six quadrat sample plots were selected from each large reed bed by using 1 x 1 m wooden frame. The results of the reed assessment were recorded on a field sheet that included follow-



Study areas in Turku and Salo, Southwest Finland.

ing parameters: coordinates of the sample point, description of the site and its surroundings, current weather conditions, level of the ice/snow, aboveground length of the stem and basal stem diameter (an average of five stems) as well as the properties of the reed material, such as hardness, straightness and colour. In addition, the colour of the lowest part of the stems was checked. We also measured the height and basal diameter of the highest stems that seem to be attractive for bird nesting. The following equipment and material was used in the field: a 1 x 1 m wooded plot frame, field sheets, a GPS navigator, clippers, Vernier callipers for measuring stem diameter, a metric ruler, a digital scale and black plastic bags.

High quality thatching reed is bright yellow, straight and hard (hard when felt and not brittle). It stands in bunches fairly uniform in length, where the average length is about 200 cm long and the average thickness 5-6 mm. It should also be durable as thatch. In addition, a high quality reed stem should be slightly reddish at its bottom. Based on these parameters, reed material was classified into four classes, ranging from the prima quality reed to reed unsuitable for thatching. The first class reed material should be homogeneous in structure and no higher than two meters tall, with a basal stem diameter 5-6 mm, coarse and straight, devoid of rubbish, such as old reed stems and the stems of other plants. Those reed stands, which are too tall or too thick or containing poor quality material cannot be used for thatching and are assigned to the fourth class of (poor) reed material. Good quality reed that, however, exceeded two and half meters, was marked as an appropriate material for reed mats.

For biomass assessment, all aboveground reed stems inside a sample plot were harvested by cutting them at ice/



Reed bed type II: Rather dry ground, thick litter layer, number of other plant species. Halikonlahti Bay, Salo. Photo: Natalia Räikkönen, 25th June 2006.



Reed bed type VI mosaic: Mosaic of dense reed and water patches. Halikonlahti Bay, Salo. Photo: Natalia Räikkönen, 30th June 2006.



A square-metre frame has been placed on the reed bed. Every stem inside the frame is counted. This is how the average number of reed stems is measured. Scientist Ülo Kask at work in spring, 2006, in Hirvensalo, Turku, Finland. Photo: Eija Hagelberg.



Reed entrepreneur Mihkel Ling is showing a Finnish group how to identify the best-quality reed for thatching. Saaremaa, Estonia. March 2006. Photo: Eija Hagelberg.

snow level and then weighed. The field weight of reed material, however, is an unstable characteristic, because moisture content may vary significantly due to the weather and site conditions. Therefore, the dry biomass should be estimated to ensure comparability between the sites. It requires determination of moisture content that can be done in a laboratory, where reed samples should be dried at 105° C for 12 hours (Alakangas, 2000).

The moisture content can be calculated as follows:

$$MC = (m1-m2)/m1$$

where

MC is moisture content of the reed sample

m1 is weight of the reed sample before drying (g)

m2 is weight of the reed sample after drying (g)

Finally, the dry reed biomass can be estimated by multiplying the field reed biomass on the moisture content and expressed in tonnes per hectare.

Fig. 2. Following vegetation types were distinguished in the study areas:

Turku			Salo	
Vegetation types	Area (ha)	%	Area (ha)	%
Reed bed types:	(95.36)		(86,61)	
I	2.47	1.9	0.08	0.1
II	10.53	8	6.95	7.5
III	5.33	4.1	5.87	6.4
IV	29.69	22.6	13.85	15
V	9.54	7.3	2.58	2.8
VI	33.49	25.5	36.91	40
VI mosaic	4.23	3.2	16.81	18.2
Shoenoplectus-rushes			0.03	0
Typha-rushes	0.08	0.1	2.49	2.7
Reed-typha rushes			0.11	0.1
Floating-leaved vegetation			0.93	1
Meadows:				
Shrub meadow	1.04	0.8	1.07	1.2
Reed meadow	10.05	7.7	1.11	1.2
Sedge- and hay meadow	12.5	9.5	1.49	1.6
Filipendula-dominated meadow	0.4	0.3	1.89	2.1
Pasture	11.84	9		
Total	131.19	100	92.18	100

Results

The results of the work are shown in Figures 2 (Turku and Salo vegetation types) and Figure 3 (Halikonlahti Bay, Salo). In latter dry biomass values and quality classes are visualized over the vegetation map. Here different colours illustrate different vegetation types and reed bed classes. The grades of biomass values are presented as dark purple circles varying in size, while classes of the reed quality are visualized by pattern-filling grades. The reed beds of *VI type* and *IV type* have been represented the most extensively in both study sites, covering, accordingly, 26 % and 23 % of the study area in Turku and 40 % and 15 % of the Halikonlahti Bay study area (Fig. 2. and Fig. 3.).

Estimates of aboveground dry biomass of reed vary in the Hirvensalo study area from 4 to 12, on average 6-7, tonnes per hectare and in reed beds along Halikonlahti Bay from 3 to 12, on average 5-6, tonnes per hectare. The quality of reed also varies significantly, not only from place to place, but even within the same reed bed. Reed on the edges of the bed is usually more thick and crooked and can be used for energy purposes. The edges are usually richer in other vegetation, because they are brighter, warmer and drier. As a result, reed material, harvested from the edges, requires more labour for separating it from other plants shoots. Inside of reed bed wind intensity declines, wetness increases and reed tends to be more dense, thin and straight and, hence, might be better suited for thatching.

Such detailed classification of the coastal wetlands was possible due to the relatively small study areas and availability of high quality aerial imagery. It should be noted also that the results of reed biomass and quality mapping have temporary nature and can vary from year to year due to the weather conditions or management practices.

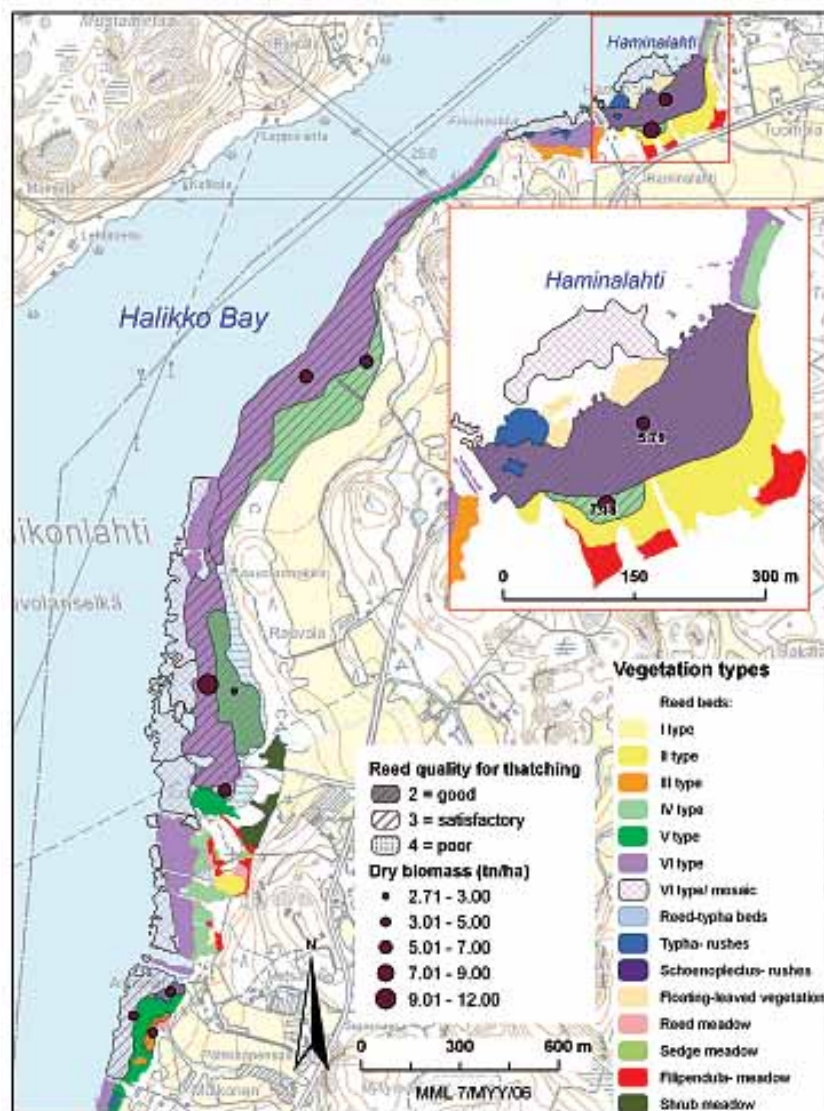


Fig. 3. Results of vegetation mapping and reed quality and biomass mapping have been put on the same map. Map: Natalia Räikkönen.

References:

- Alakangas, E. 2000. Suomessa käytettävien polttoaineiden ominaisuuksia. Valtion teknillinen tutkimuskeskus.
- Oesch, T. 1994. Vanhankaupunginlahden kasvillisuuskartoitus. Julkaisematon selvitys. Helsingin kaupungin ympäristökeskus ja Helsingin vesi- ja ympäristöpiiri.
- Ympäristösuunnittelu Enviro Oy 2005. Vanhankaupunginlahden lintuvesi-Natura 2000 -alueen hoito- ja käyttösuunnitelma. [Management plan for Vanhankaupunginlahti Bay].

Appendix 1: Scheme of coastal wetland vegetation classification.

Reed bed types:	Classification rules:
I type	Dry ground, thick litter layer, low stands (1-1.5 m), and large amount of other plant species. Typically associated species are <i>Lysimachia vulgaris</i> , <i>Lythrum salicaria</i> , <i>Phalaris arundinacea</i> , <i>Filipendula ulmaria</i> , <i>Agrostis stolonifera</i> .
II type	Rather dry ground, thick litter layer, stem length varies from 1,5 m to 2,25 m, fewer numbers of other plant species. Typical species are <i>Lysimachia vulgaris</i> , <i>Galium palustre</i> , <i>Lysimachia thyrsiflora</i> , <i>Peucedanum palustre</i>
III type	Muddy but not boggy ground, sparse reed stands, 2-2.5 m in height, large numbers of other species. Typically associated species are <i>Solanum dulcamara</i> , <i>Galium palustre</i> , <i>Caltha palustris</i> , <i>Peucedanum palustre</i> <i>Lysimachia thyrsiflora</i> , <i>Calla palustris</i> .
IV type	Wet and muddy ground, but only during the floods under the water, 2-2.5 m, scanty vegetation, large amount of old dry stems. Most likely, this is the next step of succession from the VI type. Typical species are <i>Lysimachia thyrsiflora</i> , <i>Galium palustre</i> , <i>Peucedanum palustre</i> .
V type	Wet and boggy ground, at least part of the year under the water, muddy matter content may vary from place to place, stands are 2-2.5 m tall, amount of ground vegetation also varies from sparse to dense. Typical species are <i>Solanum dulcamara</i> , <i>Lemna minor</i> .
VI type	Grows in water, exceeding 20 cm, boggy bottom; high dense stands, can be above 2.5 m, occupy edges of shores, no ground vegetation.
VI mosaic	Same as the VI type, but containing a mosaic structure of dense reed and water patches.
Rushes (Shoenoplectus-type)	Dominated by <i>Schoenoplectus</i> spp. (<i>S. tabernaemontani</i>)
Typha-type wetland	Dominated by <i>Typha</i> spp. (<i>T. angustifolia</i> or <i>T. latifolia</i>).
Meadows:	
Reed meadow	Reed is 1.5 m tall or above, but grows sparsely and not so abundant as to modify a bed; other typical species are <i>Filipendula</i> sp., <i>Deschampsia</i> sp., <i>Lysimachia vulgaris</i> , <i>Lythrum salicaria</i> , <i>Potentilla palustris</i> , <i>Galium palustre</i> & <i>Peucedanum palustre</i> . Most likely, these are tall grass meadows overgrown with reed.
Sedge meadow	Dominated by sedge.
Shrub meadow	Dominated by tall grasses and overgrown with shrubs.
Filipendula ulmaria-meadow	Dominated by <i>Filipendula ulmaria</i> , <i>Valeriana officinalis</i> / <i>Valeriana sambucifolia</i> , <i>Potentilla palustris</i> , <i>Peucedanum palustre</i> , <i>Angelica sylvestris</i> , <i>Deschampsia cespitosa</i>



Matsalu reed bed – development and use

Kaja Lotman, Director, State Nature Conservation Centre Hiiu-Lääne region

The Matsalu reed bed is one of the biggest and oldest in the coastal regions of the Baltic Sea. The first written details about the reed bed date from 1870, when the ornithologist Rus-sow and the landowner Gernet were described the extensive (almost 10 km² in total) reed bed in the Kasari river delta. The reed bed had Common Reed, bulrush and calamus, with larger clumps of sedge growing in between.

In 1925, E. Kumari estimated the Matsalu reed bed to be 15 km² in size and he reported that the reed bed was spreading towards the west in the shallow waters of the bay and towards the east along the riverbanks (Kumari, 1973). By 1983 the reed beds' surface area had grown even further. According to Ksenofontova (1985), the surface area of the reed bed was then 27 km², and it stretched from east to west for a distance of 6 km and from north to south for a distance of 5-8 km.

Five basic reed types can be distinguished in Matsalu (Ksenofontova, 1985):

1. Common Reed beds (82%)
 - 1.1. Marine reed beds (52%)
 - 1.2. Land reed beds (19%)
 - 1.3. Land reed beds with sedge growth (29%)
2. Cattail stands' poles (8%)
3. Bulrushes (9%)
4. Maritime club-rush (0.3%)
5. Calamus and reed sweet grass (0.1%)

As a result of decomposition and paludification following changes in the water level, the current vegetation in the reed beds is slightly different. The habitats of cat's-tail and club-rush have expanded, and there seems to be more reed sweet grass. Large groups of iris grow in the reed beds.

The main factors affecting the size, structure and dynamics of a reed bed in Matsalu and the western coast of Estonia are as follows:

1. Postglacial landlift and the resulting terrestrial changes. Due to this factor, the western boundary of the Matsalu reed bed has moved by as much as 5 km in 100 years (Meriste 2003).
2. Eutrophication
3. Coastal meadow management by grazing and mowing



The vast reed beds of Matsalu Bay can only be seen from a watchtower near Suitsu River, or else from the air. Photo: Ivar Ojaste.

The above mentioned continuing growth in the reed bed's surface area is, in the main, due to the shape of the Matsalu-Kasari Valley. In the 1980s, the biggest and widest part of Matsalu Bay reached an ideal depth for the spread of reed beds, due to the isostatic uplift of the area. Further growth of the surface area of the reed bed is not possible because the valley gets narrower in



Active grazing keeps the coastal meadows open and flat. Cows, especially, are good grazers in reed bed areas, as they do not avoid moist or even wet areas. Haeska, Matsalu National Park. Photo: Iiro Ikonen.

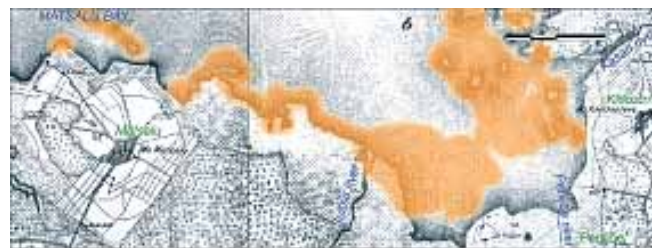
the west (Meriste, Üts, Kirsimäe, 2005). We can only observe internal structural changes and thickening of the reed bed (Meriste, Üts, Kirsimäe, 2005).

Eutrophication has probably been the fate of Matsalu Bay throughout history. In particular, in the 1960s, the 1970s and the 1980s water containing large amounts of nutrients flowed along the rivers into Matsalu Bay. The height of the reed and the thickness of its stems increased, with the result that the reed bent over and became more brittle (Ksenofontova, Polma, 1987). The rapid expansion of the reed bed was blamed on agriculture.

If the surface area of the delta's reed bed appears to be growing smaller, the decrease in human activities in the coastal regions in the 1980s and 1990s resulted in the expansion of the Matsalu Bay reed beds along the southern and northern shores to the former coastal meadows of Haeska and Keemu, and also to the islets (the peninsular of Sassi, the area of Tauksi, Haeska reefs, Saardo and Kiideva shores, lower shore of the Puinen Forest, Rooglaiu peninsular, etc).

The bird population of Matsalu in the past 135 years

The first mention of the area's bird-life is from 1870, when the curator of Tartu VIST University Zoological Museum, Valerian Russow, first focused his attention on the local bird population. On his journeys, he studied the presence and nesting habits of 52-53 bird species. Since then, the area has attracted several other ornithologists, each of whom has found something new. Immediately before the area was dredged in 1920-30ies, Mihkel Härms stayed here for almost one month. He focused on the bird population of the river delta. A more thorough study of Matsalu Bay was undertaken by Eerik Kumari (Sits), whose initiative in 1957 led to the foundation of the Matsalu nature reserve.



The development of South-Eastern Matsalu bay reed beds 1900 - 1951 - 2005. Maps: Mats Meriste.



The surface area of Matsalu Bay reed beds is approximately 2,700 ha. Ornithologically the reed can be divided into several zones (Onno, 1963; Paakspuu, Kastepõld, 1985):

- 1) almost dry, low reed bed close to the shore with Sedge Tussocks and a few Willow bushes;
- 2) homogenic tall reed bed, with tall and thick reed stems; thick, shallow-water reed bed without open water areas
- 3) in several of the water areas, a mosaic of reed bed and bulrushes;
- 4) individual reed plants in open water.

The almost dry, low reed bed close to the shore, with its sedge tussocks and willow bushes, has moved several hundred metres further to the west during the past 30-40 years. In several places where reed used to grow, nowadays tall Sedge Tussocks, Reed Sweet Grass and Iris thrive. At the same time, islands of almost dry, low reed bed, with Sedge Tussocks and sometimes Willow bushes, can be found some way from the shore inside the eastern reed bed, for instance near the hummock of Täku. In summertime, low reed beds grow scattered in the area, and there are plenty of other types of grasses: Iris, Sedges, Reed Sweet Grass, Horse Mint, Cuckoo Flower, Greater Spearwort, Marsh Pea, Spike-rushes etc.

On the other hand, areas of drier, raised reed beds have started to invade several places. At the end of the 1970s, the entire seashore at Matsalu, and the seashore on the Suitsu side of Lihula village, had been overrun by drier, raised reed beds, and a thin belt of them was also found at the edge of the flood-plain. Of late, the surface area of these reed beds has grown continuously, particularly at the edge of the flood-plain. In winter, reed is mainly harvested from the drier, raised reed beds.

The main section of the eastern part of the reed bed comprises a dense, shallow reed bed with little open water, which makes up of the total mass of reed growth.

According to aerial photos, there is still a thin belt of dense deep-water reed bed running north-south in open water in the mass of reed beds in the river between

Kasari and Rõude, approximately between the mouth of the river Suitsu and the end of the Rõude canal. This kind of reed bed has always been the habitat of the most diverse of reed bed bird populations. The reed bed north of the of Rõude River only contains a few patches of open water. The strip of open water also runs along the Matsalu marine reed bed, which is beyond the bank of the Kasari river. The habitats on the western fringes of the reed bed have remained almost intact but, over time, have moved considerably to the west.

About 70 years ago the reed bed of Matsalu was structurally very different. In the continuous reed bed there was 10-20% of open water in small and larger patches, whereas towards the open sea the amount increased to 30-40%, and in the reed mosaic area of the outer zone, it increased to as much as 60-70%. (Kumari (Sits), 1937).

Alongside the changing reed bed, the nesting bird population has also changed to a great degree. The large colonies of Black-headed Gulls have disappeared. No-one knows the reason for their disappearance. The number of Little Gulls in the reed bed before dredging varied a lot, but it continued to be a common nesting bird. Since 1965 this species has not nested in the reed bed as far as is known, but it is possible that a couple of pairs may have done so. There are fewer little gulls hovering above the reed bed year upon year, other than the oc-

Monitored bird species In Matsalu		Years				
		1870	1924	1928-1936	1958-1960	1977-1980 2002-2003
Great Crested Grebe	PODCRI		++	40	140	140 110-150
Bittern	BOISTE	++	++	25	15	18 30-56
Bewick's Swan	CYGOLO			0	0	25 70-130
Greylag Goose	ANSANS	++	++	160	140	200 70-100
Mallard	ANAPLA	++	+++	+++	230	>250 200-260
Pintail	ANAACU	++	+++		2	
Garganey	ANAQUE	++	++			30-70
Showeler	ANACLY	++	++			6
Pochard	AYTFER	++	+++	225	150	150 20-30
Tufted Duck	AYTFUL		+	90	0	10 10
Marsh Harrier	CRAER		++	40	30	18 20-22
Water Rail	RALAQU			50	55	70 150-400
Spotted Crake	PORPOR	++		++	75	80 120-1160
Little Crake	PORPAR	+	+	20-25	20	20 0-10
Corncrake	CRECRE					3-220
Black cool	FULATR		++	1000	1150	600 70-100
Moorhen	GALCHL					12-18
Snipe	GALGAL					55-200
Little Gull	LARMIN	++	++	100	60	0
Black-headed Gull	LARRID	++	++	5500	2260	6000
Black Tern	CHLNGB	++	1	260	140	150 35-50
Yellow Wagtail	MOTFLA			(+)		700-650
Savi's Warbler	LOCLUS					10 2700-3100
Sedge Warbler	ACRSCH		++	80	82	80 5000-6000
Reed Warbler	ACRSCI			10	65	100 770-1200
Great Reed Warbler	ACRARU	++	+++	84	170	170 450-730
Bearded Tit	PANBIA					11-100
Reed Bunting	EMBSCH		++	70	175	200 5500-7000

Number of birds nesting in the reed bed in 1870-2003. Earlier literature (Jõgi 1952, Härms 1926, Kumari 1937, Onno 1963, Paakspuu, Kastepõld 1985). +++ and ++ means that the species is dominant, frequent or common; + means that the species occurs.

casual feeder. The occurrence of Black Tern has always been variable. Nowadays the numbers hover around the 30-50 figure, and in some years there may even have been fewer.

Mute Swans are the distinctive feature of the reed bed: they can be seen from far afield and the species is particularly well represented on the outer fringes of the reed bed. The number of Bittern has grown. During the latest inventory of species, the number of Water Rails and Spotted Crakes was established particularly well; there were masses of both. The number of these two species has varied a lot over the years, as has their activity: in 2002 there were 4.6 times fewer water rails and 17.3 times fewer spotted crakes in dry and bent reed stems than there were during normal water levels and in upright reed in 2003. During dry summers Corncrakes nest in the reed bed.

There are numerous Passeriformes living in the reed bed. The Sedge Warbler is common in the thinner and shallower part of the reed bed, and on riverbanks. In drier and denser sections of the reed bed there are fewer of them; these sections

are dominated by Reed Warblers and Great Reed Warblers. The reed bed is full of Reed Buntings and Savi's Warblers. There are plenty of Yellow Wagtails, whose occasional nesting place has been the previously mentioned Kumari.

The first signs of human activities in Matsalu region date from the Stone Age, and the area became permanently inhabited in the Middle Iron Age (between the 6th and 9th centuries). Reed roofs were popular in the Matsalu region till the end of the 20th century, but the old tradition have still not declined. Incidents are known from the 1930s, in which the farms along the shoreline planted reed in the shore areas in order to have a supply of it close by.

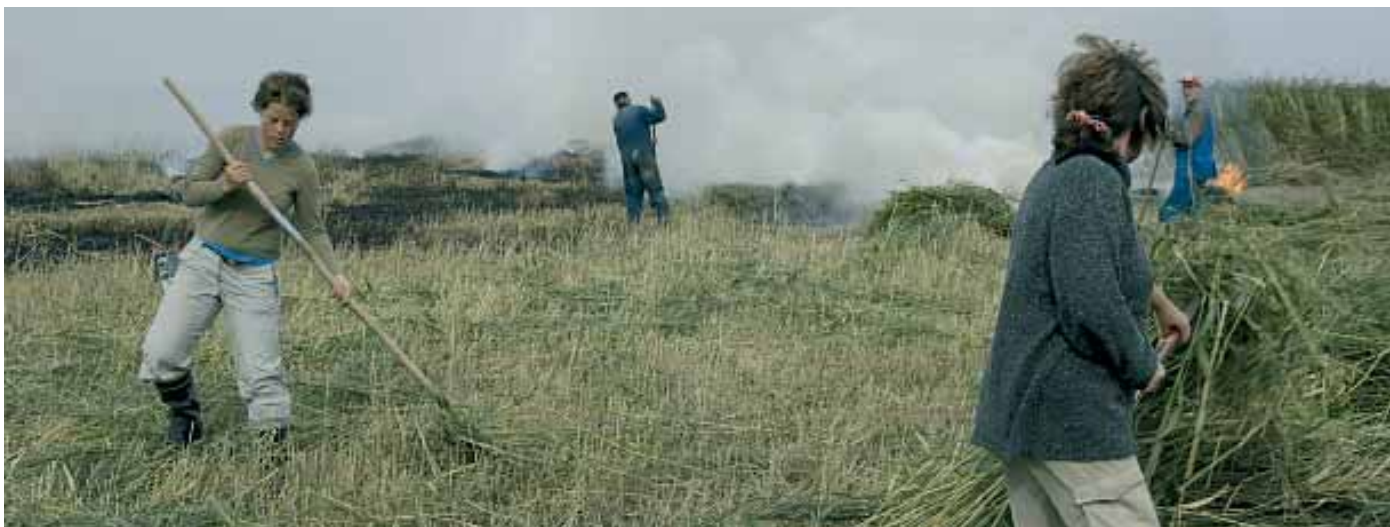
Reed was also used in other ways: it was used for reed pipes and bagpipes, mats and fences, insulation for walls and, in springtime, for animal fodder. In times of trouble, people were even known to have hidden in the reed beds. The reed bed guards became a phenomenon in their own right. The life of one such guard is told in a children's story book.



A magnificent display of male Great Snipes playing in their leks can still be seen in Matsalu, but not in Finland anymore. But what about the future? Will proactive management make it possible to re-establish the species in coastal meadows in Finland too? Photo: Antti Below.



*Old fishermen's huts along the Suitsu River in the southern part of Matsalu National Park. Some of the reed roofs on these huts are nearly 100 years old.
Photo: Eija Hagelberg.*



Coastal meadow management at a voluntary camp in Matsalu National Park in summer 2006. Photo: Keijo Luoto.

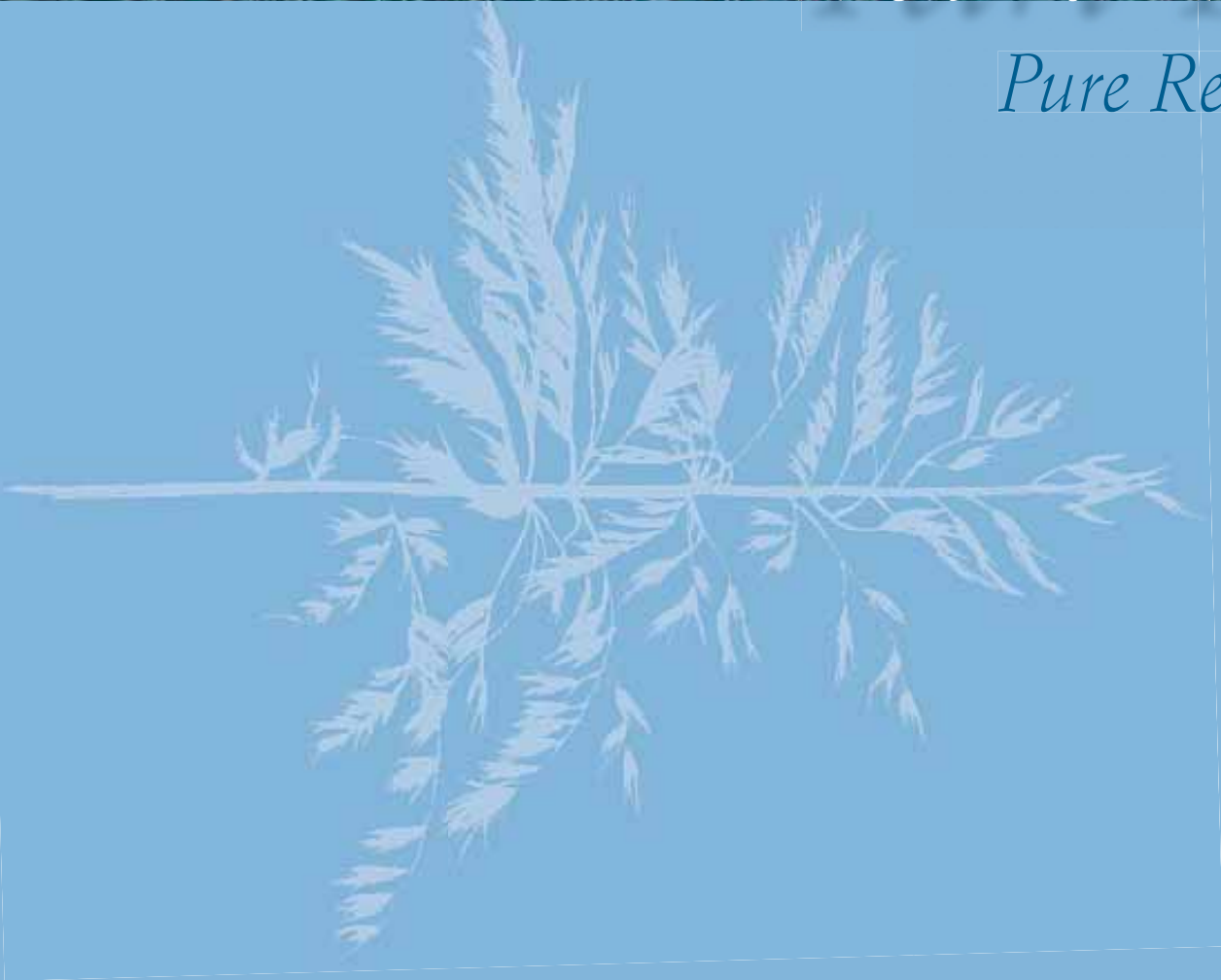
References:

- Erit, M., 2006. Silma looduskaitseala tähtsus niidu- ja roostikulindude pesitsusalane Eestis. – *Hirundo* 19 (2), lk. 58-67.
- Erit, M., 2006. Rannaniidu- ja roostikulindude asustustihedus Silma looduskaitsealal ja Eestis. – *Loodusevaatlusi* 2006. Penijõe, lk. 32-49.
- Härms, M., 1926. Matsalu lahe ja selle ümbruse linnustikust. – *Loodusuurijate Seltsi aruanded* 32, lk. 55-78.
- Jõgi, A., 1952. Russowi reisid Baltimaade linnustiku tundmaõppimiseks. Tartu (käsikiri Matsalu LKA raamatukogus).
- Ksenofontova, T., 1985. Matsalu lahe pilliroog ja roostikud. – *Matsalu – rahvusvahelise tähtsusega märgala*. Tallinn. Lk. 113-125.
- Ksenofontova, T. & Polma, G., 1987. Roostike taimeistiku ja linnustiku muutustest käesoleval sajandil. – *Matsalu Riikliku Looduskaitseala ökosüsteemide dünaamika ja seisund*. – *Matsalu Riikliku Looduskaitseala 30. aastapäevale pühendatud teaduslik-tehnilise konverentsi ettekannete kokkuvõtteid*. Lihula, 1. august 1987. a. Tallinn, Valgus, lk. 56-66.
- Kumari (Sits), 1937. Materjale Matsalu lahe linnustikust. Tartu, 328 lk.
- Kumari, E., 1973. Matsalu maastiku looduslike komplekside kujunemisest viimase 100 aasta vältel. – *Matsalu maastik ja linnud*. Ornitoloogiline kogumik VI. Tallinn, lk. 28-39.
- Meriste, M., 2003. Settekuhjumine Kasari deltas ja Matsalu lahe maismaastumine. Bakalaureusetöö. Tartu Ülikooli geoloogia instituut, Tartu, 64 lk.
- Meriste, M., Üts, M. & Kirsimäe, K., 2005. Matsalu märgala roostike struktuuri ja leviku muutused aastatel 1980-2004. – *Loodusevaatlusi* 2004-2005, Lihula, lk. 3-18.
- Mägi, E., 2003. Kasari luha ja Matsalu siselahe roostike linnustik ning veerežiimi muutmise mõjust sellele. – *Loodusevaatlusi* 2000-2002, Lihula, lk. 105-134.
- Onno, S., 1963. Matsalu Riikliku Looduskaitseala haudelinnustikust. – *Ornitoloogiline kogumik* III. Tartu, lk. 23-56.
- Paakspuu, V. & Kastepõld, T., 1985. Matsalu märgala vee-, soo- ja rannikulinnustik. – *Matsalu – rahvusvahelise tähtsusega märgala*. Tallinn. Lk. 215-235.



Part II

Pure Reed



To cut or not to cut?

The relationship between Common Reed, mowing and water quality

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Reed belongs to the *Poaceae* family. Common Reed – in Latin *Phragmites australis* (Cav.) – is one of the most widely found vascular plants in the world, occurring on all continents except Antarctica. Common Reed is one of the dominant plant species in European land-water ecotones (van der Putten, 1997). The species is perennial; its basal stem is upright and usually 1-3 metres high. In nutrient-rich areas it can grow even taller. The leaves are long, 1-2 centimetres wide, green, and sharp-edged. The flowers are thick, approximately the size of the palm of your hand. The flowers will not develop in poor habitats, where reed grows as a “habitat relic” (Jalas 1958: 348). The size of the inflorescence also depends on the quality of the habitat. Reed thrives in wetland habitats and grows in fresh or in brackish water. In different habitats the genetically similar clones of this adaptable species may seem remarkably different.

Reed has an extensive creeping rhizome, and the upturned ends of its branches develop into an aerial shoot (Jalas 1958: 351). Reed sometimes produces a shoot up to 10 metres away from the rhizome, and the shoot may end up growing in a place that appears rather dry. It is sufficient that a part of the rhizome is in a moist habitat. Reed receives its nutrients by means of an extensive underground rhizome that extends to a depth of between 5 and 35 centimetres. It also has thinner roots of over 50 centimetres in length which grows both horizontally and vertically. Nutrients stored in rhizome are important in the beginning of the growing season. With these reserves, the plant ensures its survival in challenging habitats (Graneli et al., 1992: 161). Reed often improves the oxygen content of oxygen poor sediment by releasing oxygen into the sediment through its extensive rhizome. The lifespan of the rhizosphere is approximately 5-7 years. In polluted and eutrophicated areas, the rhizome biomass is low, but the shoot is outstanding (Gries & Garbe 1989).

At its densest, a reed bed may contain as many as 300 shoots per square metre, but the average density is between 40

and 100 per square metre (Jalas 1958: 351). In Finland, the species flowers in the end of summer and the seeds ripen in mid-winter. After flowering, the reed stems turn woody, shed their leaves, and remain upright through the ice. Reed seeds germinate in Finland at the rate of 3-44% (Jalas 1958: 351). The seeds are dispersed in late winter by the wind. Vegetative spread by below-ground rhizomes is common (Saltonstall, 2003: 12, [amongst others]). Colonization of reed occurs through the rhizome and roots “hidden” in the ground and it can colonize new areas many metres per year. Deep water may stop vegetative colonization of new habitats. If reed has colonized new area, it does not always suppress the growth of other species during one growing season. Dominance and monoculture may develop after several years (Güsewell 2003: 433-434). Reed often dominates land-water interface and forms monocultures. Reed’s stem and leaves grows almost always above the water level. Overwintering green buds of reed are in the underground parts of the plant. Overwintering occurs in green overwintering buds but the new green leaves emerge only in spring (Ellenberg et al. 1992: 67-76).

The depth of water impacts the occurrence of reed. Oxygen transport capacity of reed is related to the water depth. The deeper it grows, the more difficult it is for it to transport oxygen into the roots. The optimum salt tolerance of the species is 0-15 per mils. The colonization of reed into new areas can also be affected by waves, environmental disturbance, competition with other plant species, and probably nutrient load (Weisner & Strand 2002). Reed can lower the sulphate content in the upper organic layers of sediment, which leads to a more vigorous growth. This enables reed to colonize harsh environments (Bart & Hartman 2000: 66-68). Reed can oxygenate the sediment around its roots and thereby prevent itself from taking in toxic substances from the sediment (Gries et al. 1990, 589-590). The occurrence of reed indicates slightly acid and nitrogen-rich conditions (Ellenberg 1992).

Reed grows usually in hard sediment with low amount of



Reed can colonise large areas aggressively. It can grow densely, the average density is between 40 and 100 shoots per square metre. Photo: Eija Hagelberg.

organic matter. In soft sediments and in sheltered locations, this species usually is not good in competition with other plant species. If reed grows on a soft surface, it is often grazed, because animals can have access to its roots by pulling the stem.

Reed has been studied extensively, but its impacts on the water quality are not entirely clear, and some results of the research are contradictory. Because reed is a common and often abundant species, it is highly significant for many water and land ecosystems. In general, aquatic macrophytes are very important factor governing the nutrient levels in aquatic ecosystems (Phillips 2006: 266-278).

Reed and water quality

Aquatic macrophytes commonly stabilizes the sediments and reduces the impacts of water movements on the sediment of water bodies (Vermaat et al. 1990, [amongst others]) and it is commonly known that they reduce the growth potential of algae (Phillips 2006). Aquatic macrophytes can also have an indirect effect on the nutrient levels, because they improve the habitat of predatory fish. These fish, in turn, can have

a significant impact on the biomass of the fish that enhance the eutrophication (i.e. bream and roach) (Jeppesen & Sammalkorpi 2002, 298). Aquatic vegetation suppress the impact planktivorous fish on the zooplankton because of the increased shelter for zooplankton. Micro-crustaceans living in aquatic vegetation can reduce the biomass of phytoplankton remarkably (Vakkilainen 2005). Aquatic macrophytes can also shade the phytoplankton and thereby affect its growth and biomass (Jeppesen & Sammalkorpi 2002, 298).

Research by Toivonen and Huttunen (1995) and Maristo (1941) supports the general view that there is a strong link between aquatic macrophytes and eutrophication. This link is obvious in water bodies that are naturally eutrophic (a strong positive correlation between nutrient levels and the biomass of aquatic macrophytes at the land-water interface). The nitrogen content of reed stems is also high in the shore areas of eutrophic lakes probably because reed retains nutrients coming from the catchment area (Kvet 1973, Sandström 2007).

If nutrient load of water ecosystem is constant and high, aquatic macrophytes are able to control the biomass of phytoplankton (Vakkilainen 2005). In eutrophic and algae-rich water bodies, the biomass of aquatic macrophytes will usu-

ally remain high even if the external nutrient load decreases. In some cases, nitrogen is limiting the growth of algae (van Donk et al. 1993). The nitrogen intake of aquatic macrophytes is known to be linked with the rhizosphere and its surrounding sediment (Risgaard-Petersen & Jensen, 1997). Aquatic macrophytes that have both roots and aerial shoots, such as reed, can keep the phosphorus locked in the sediment. The release of oxygen from the roots can lead to the oxygenation of iron, and this in turn leads to the retention of phosphates. Aquatic macrophytes can also increase the phosphorus levels in the water, because of the decomposing plant mass followed by a sedimentation and an increase in organic matter (Moss et al. 1986).

The impacts of the cutting during the growing season

During a cut, only small quantities of nutrients are removed from water bodies along with the reed biomass, because the biomass is nutrient poor (0.16-2.2% of the plant mass) (Asaeda, 2002). In yearly cutted areas, the reed remains small, but cutting has no impact on nutrient contents. Early summer cutting increases the leakage of nutrients into the environment. Later on in the growing season, no more leakage occurs (Uhlenius 1996, Güsewell 2003, Kojo 2006). Intensive cutting in June during several years caused decline of reed, because the nutrient storages in root system will be exhausted. Reed cutting above the surface of the water restricts the growth of the shoots, but if you want to remove the reed totally, it should be cut below the surface, to stop oxygenation. This must be done early in the summer, if reed is growing in muddy substrates. Nutrient supplies in the rhizome are at their lowest 7-10 weeks after the start of spring growth (in Finland this is at the end of July/beginning of August) and cutting is most advantageous at this time (Weisner & Graneli 1989, Asaeda et al. 2003). Cutting in the end of August will have no impact on future growth, because the reed has already stored enough nutrients in root system for the next growing season (Weisner & Graneli 1989: 71 -80). The recession of a reed bed will take 3-5 years, depending on the characteristics of the location, such as the quality of the bottom sediments. When the reed bed recession occurs, loose stems above the surface may increase the need to clean the shore areas.

The effects of the cutting on the water quality are also dependent on the size of the cut area, the total surface area of the reed bed and its location. The removal of reed beds from the shore areas of the islands closest to the mainland must be



In early summer (June) there are a lot of nutrients in the stem and the leaves of reed, which makes it a nutritious and delicious food for cattle. Early summer cutting is the most effective way of eliminating reed. Reed cutting for cattle fodder, carried out in Mietoinen, Southwest Finland, on 26th June 2007. Photo: Kimmo Härjämäki.



Late summer reed harvesting (July and August) is the most effective way of reducing nutrients from the sediment, because at this time of the year most of the plant's nutrients are found in the stem and leaves. This material could be suitable for biogas production, cattle doesn't like it. Reed cutting in Joroinen, Southern Savolax, Finland on 26th July 2007. Photo: Eija Hagelberg.



viewed with caution, because reed has a positive impact on the retention of nutrients in such locations. In areas far from mainland, the impact of reed on nutrient levels in water is probably lower (Lindholm, 1989 [amongst others]), but the role of the reed in nutrient dynamics of brackish waters is not totally understood. If the littoral zone of oligotrophic water body is narrow and deep, the importance of reed and horsetail in retaining nutrients in the sediment is not significant (Nurminen 2003: 16). The plant mass that is removed should be taken far from the shoreline immediately after it has been cut, in order to prevent nutrient leakage back to the water ecosystem. Plant mass can be composted or used as animal fodder. Kairesalo and Uusi-Rauva (1983) have noted that dead horsetail detritus may cause a phosphorus load that is 300 times greater in littoral water than that caused by actively growing horsetail. Falsely managed reed beds are notable sources of methane, particularly in spring (Sorrell et al. 1997). Thus, the removal of reed beds can also have negative effects on the emission of greenhouse gases, if not properly done.

Current practice and recommendations for the removal of the reed

According to current recommendations, reed should be removed by the following methods (Kirkkala & Kipinä 2003: 8, Suomen ympäristökeskus 2004: 5):

Common Reed should be removed from as close to the bottom of the lake or sea as possible. Removal should not be undertaken in large areas, as doing so may release nutrients that can be used by phytoplankton, such as blue-green algae. Aquatic macrophytes also protect shores from erosion caused by waves and water currents and keeps nutrients and solid matter in the sediment. To maintain the beauty of the landscape, the reed should be cut in a way where vegetation and open water areas are in balance. Cutting is effective if it is carried out in the following way:

- In the first summer, when the reed is cut, it should be cut twice: the first cut is good to do just before the flowering (at the end of June), and the second cut 3-4 weeks later.

- In the second summer when the reed is cut, it should be cut once, between mid-July and mid-August. It is useless to cut the reed later in the season.

- From the third summer onwards, cut when necessary.

The impacts of reed cutting in winter

The carbon dioxide originating from plant rhizome respiration and sediment decomposition, and methane produced in the sediment by inethane-producing microbes are released into the atmosphere also in winter via dead reed stems that stick out from ice cover. The capacity of reed to carry oxygen is not sufficient to help with the reed-cleansing process in wintertime, but the aerobic metabolism of the reeds rhizome is sufficient for it to maintain all other vital functions. Reed cleansing is therefore not a viable option in northern climates: in wintertime, the nutrient-rich waters will not be cleansed because the reed cannot transfer sufficient oxygen from the atmosphere into the sediment. The rhizosphere (made up of the reed and its rhizome) and its surroundings involve processes that are typical of oxygen-free environments. The reed stems are an important escape route for the carbon dioxide that is generated through respiration. Methane, which is produced by the microbes that operate in the sediment, is released directly from the anaerobic sediment. In wintertime the dead stems of reed form a significant pipe system, through which the gases that result from metabolism are carried in both directions; from the sediment into the atmosphere and, in the case of oxygen, from the atmosphere through the stem back into the sediment (Brix 1989: 81-98).

Removing the reed in wintertime increases the above-surface biomass in the next growing season. It also increases the density of shoots in the next summer. Oxygen transport to roots and rhizomes in winter is obviously an important function of dead shoots. Haslam (1971) recognised, that winter cutting increases the density of shoots, not their speed of growth in next summer. In narrow reed beds ice often cuts the reeds, but this has no impact on the following season's growth. The positive impact of winter cutting on the fitness of reed beds was obviously the result of a decrease in the number of hibernating insects, and an increase in the amount of light available to the emerging shoots. The reed stems which were cut from the ice have often dense population of wintering insects. Thus these insects will not graze the reed and the other aquatic macrophytes in next growing season, if the reed is cut (Granéli 1989: 105). On the other hand, this weakens the biodiversity invertebrate populations in reed bed, and will also have a negative impact on the bird populations in reed bed (Ditlhogo et al. 1992). It seems that winter cutting has a positive impact on the vitality of the reed bed, which in turn may improve the reed beds ability to retain nutrient load from catchment area.



There are two benefits to winter harvesting: 1) the decomposing, oxygen-consuming biomass is removed, which improves water quality, and 2) the reed itself can serve as a raw material for thatching, other types of construction, bioenergy and as mulch in gardens. Without winter harvesting, reed rafts drift ashore. Photo: Eija Hagelberg.

Winter cutting will make summer cutting easier particularly in shallow-water areas, and may be a cost-effective way to start reed cutting.

Cutting channels in reed beds

Channel cutting in large reed areas is beneficial for biodiversity. Enhanced mosaic variation in reed beds is known to increase numbers of fish, plants and other organisms living reed bed (Goc et al. 1997, Able & Hagan 2003, Poulin & Lefebvre 2002: 1567). Channel cutting close to the land-water interface should be avoided, because it could increase the runoff of nutrient-rich waters from the catchment area into the water ecosystem. Reed cutting will often increase living space for other aquatic macrophytes, such as rush and submerged plants (e.g. Kojo 2006), and submerged macrophytes, which can be more effective in retaining nutrients than reed (Eriksson & Weisner 1998: 1996). On the other hand, reed is not always such a significant source for methane emission as, for instance, Water Lily (*Nuphar lutea*) or Water Horsetail (*Equisetum fluviatile*) (Bergström et al. 2007: 347).

Channel moving can enhance the growth of phytoplankton, and the effects of channel cutting on the nutrient levels in water ecosystems must be evaluated carefully. It is not advisable to plan channel or mosaic moving near agricultural areas, ditches or river estuaries. It is also not clever to move narrow reed zones between fields and wetland areas. These reed zones are known to retain nutrients of runoff waters originating from terrestrial areas in the summer, i.e. the biomass of aquatic macrophytes correlates positively with the nutrient load of the aquatic ecosystem (Maristo 1941, Toivonen & Huttunen 1995, Saltonstall 2003: 12 -15). Channel cutting in large reed beds may be useful if it diversifies fish habitats and if cutted channels are colonized by submerged macrophytes. In this way biodiversity improves, and the diversified vegetation has positive impact on the fish population and the amount of zooplankton, which will control the biomass of phytoplankton.

Reed burning as removing method

In March and April, when the previous years reed biomass is driest, it is possible to remove reed beds from the ice by burning it. Shoots will not get damaged, if the burning is carried out early in the spring (for example in March), but some damage will occur if the reed is burned in the mid April, when

growth has started. Burning seems to be an effective method for removing the reed in late summer, but in winter and in spring it seems to increase the density of reed shoots in next growing season (Cross & Fleming, 1989). Reed burning in the late summer in northern areas is not easy, because the water content of reed is high. The impact of the reed burning on the water quality has not been studied. The ash of reed is very rich in silicon (Isotalo et al. 1981).

The fire has severe impact on the next seasons growth of reed only if it impacts the soil deeply (van der Toorn & Mook, 1982). Reed burning reduces the amount of oxygen and thus weakens the viability of reed if the water level is high. The decline of reed bed will occur after burning if there is a flood afterwards, which weakens the oxygen transportation capability of reed (Rolletschek et al. 2000). Reed burning is an effective mean to destroy reed mass. It does not produce harmful methane emissions, which will happen if reed biomass decomposes in oxygen poor conditions.

Recommendations

The removal of reed must always be carried out with care, and the possible effects of burning on nutrient levels in water ecosystems and on water organisms must be studied on a case-by-case basis. The overall effects of reed on water quality cannot always be predicted because many of its impacts are indirect, and the cutting of reed can, for instance, increase the growth of other aquatic macrophyte species and thus diversify the habitats of zooplankton and fish. Mosaic and channel cutting of large reed beds is useful in general, and probably doesn't increase the nutrient release from the sediment. If other aquatic macrophyte species colonize cutted channels, it may be beneficial for the water ecosystem. Other methods of removal may also be used in certain circumstances. If it becomes necessary to remove entire reed beds, it should be done carefully. Reed may recover from even persistent attempts to remove it, because it has remarkable stores of nutrients in its underground root systems. Shoot cutting should always be done below the water level, if the aim is to stop reed growth completely. It is advisable not to remove reed beds between fields and wetlands, or along ditches or river estuaries. Removing reed from these habitats can have a negative impact on water ecosystems, because it can increase the amount of nutrient flow into water ecosystem and thus enhance eutrophication. On important issue in the management of reed beds is that moving of reed can have substantial effects on greenhouse gas emissions. False management practices may increase the emis-



Students making water-quality measurements in a channel in the reed bed at Laukanlahti Bay, Perniö, Finland. Photo: Eija Hagelberg.

sions of greenhouse gases into the atmosphere. Extensive cutting of reed beds may also increase living space for other aquatic macrophytes, which can increase emissions more than reed. Reed cutting in large areas enhances the growth of phytoplankton, because of the increased open water areas, which are beneficial for phytoplankton and of the decreased competition with aquatic macrophytes.

References

- Able K.W. & Hagan S.M. 2003. Impact of Common Reed, *Phragmites australis*, on Essential Fish Habitat: Influence on Reproduction, Embryological Development, and Larval Abundance of Mummichog (*Fundulus heteroclitus*). – Estuaries 26.
- Asaeda T., Manatunge J., Fujina T. & Sovira D. 2003. Wetlands Ecology and Management 11: 127-140.
- Bart D. & Hartman J.M. 2000. Environmental Determinants of *Phragmites australis* Expansion in a New Jersey Salt Marsh: An Experimental Approach. Oikos 89: 56-69.
- Bergström I., Mäkelä S., Kankaala P., & Kortelainen P. 2007. Methane Efflux from Vegetation Stands of Southern Boreal Lakes: An Upscaled Regional Estimate. Atmospheric Environment 41: 339-351.

- Brix H. 1989. Gas Exchange through Dead Culms of Reed, *Phragmites australis* (Cav.) Trin. ex. steudel. *Aquat Botany* 35: 81-98.
- Brix, Hans, Sorrell, Brian K. & Orr, Philip T. 1992. Internal Pressurization and Convective Gas Flow in some Emergent Freshwater Macrophytes. *Limnology and Oceanography*.
- Cowie N.R., Sutherland W.J., Dithlago M.K. & James R. 1992. The Effects of Conservation Management of Reed Beds II. The Flora and Litter Disappearance. *J. Appl. Ecol* 29: 277 -284.
- Cross D.H. & Fleming K.L. 1989. Control of *Phragmites* or Common Reed. U.S. Fish and Wildlife Leaflet 13.4.12. 5pp.
- Dithlago M.K.M., James R., Laurence B.R. & Sutherland W.J. 1992. The Effects of Conservation Management of Reed Beds. I. *J. Appl. Ecol.* 29: 265-276.
- Eriksson P.G. & Weisner S.E.B. 1998. An Experimental Study on the Effects of Submersed Macrophytes on Nitrification and Denitrification in Ammonium-rich Aquatic Systems. *Limnology and Oceanography* 44(8) 1993-1999.
- Granéli W. 1989. Influence of Standing Litter on Shoot Production in Reed, *Phragmites australis*. *Aquat Botany* 35, 99-109.
- Granéli W., Weisner S.E.B. & Sytsma M.D. 1992. Rhizome Dynamics and Resources Storage in *P. australis*. *Wetl. Ecol. Management* 1: 239-247.
- Gries C. & Garbe D. 1989. Biomass and Nitrogen, Phosphorus and Heavy Metal content of *Phragmites australis* During the Third Growing Season in a Root Zone Waste Water Treatment. *Arch. Hydrobiol.* 117: 97-105.
- Güsewell S. 2003. Management of *Phragmites australis* in Swiss Fen Meadows by Mowing in Early Summer. – *Wetlands Ecology and Management* 11 (6): 433-445.
- Haslam 1971. Shoot Height and Density in *Phragmites* Stands. *Hydrobiologia* (Bucuresti) 12: 113-119.
- Isotalo I., Kauppinen P., Ojanen T., Puttonen P. & Toivonen H. 1981. Järviruoko energiakasvina. Tuotosarvio, tekniset mahdollisuudet ja ympäristönsuojelu. [Energy from Reed in Finland, Potentials and Constraints]. National Board of Waters, Finland. Report 210. 48p.
- Jalas J. 1958. Järviruoko (Reed), publication: Suuri kasvikirja (The Big Book of Plants).
- James 1988. The Post-fire Environment and Earthworm Populations in Tallgrass Prairie, *Ecology* 69: 476-483.
- Jeppesen & Sammalkorpi, I. 2002. Lakes. In publication: Perrow M.R. & Davy. A. Handbook of Ecological Restoration. Published by Cambridge University Press.
- Kairesalo T. & Uusi-Rauva A. 1983. Phosphorus Release by an Emergent Macrophyte: Significance to Epiphyton. *Proc. Int. Symp. Aquat. Macrophytes*, Nijmegen, 18-23 September, 1983: 101-110.
- Karunaratne S., Asaeda T., & Yutani K. 2004. Shoot Regrowth and Age-specific Rhizome Storage Dynamics of *Phragmites australis* subjected to Summer Harvesting. *Ecological Engineering* 22: 99-111.
- Kirkkala T. & Kipinä S. 2003. Lounais-Suomen järvikunnostusopas, opas nro 1 [Southwest Finland Lake Maintenance Guide; Guide No. 1]. Lounais-Suomen ympäristökeskus, opassarja, vesi Southwest Finland Environment Centre; Guide Series, Water).



Burning reed in early spring in Mietoinen, Finland. Burning old reed in spring makes the coastal meadow suitable for grazing cattle in early summer, as old reed is not suitable for the nourishment of cattle. Burning should no longer be carried out once birds have begun nesting. Photo: Emil Raimoranta.



- Kojo Janne 2006. Ruoikon väyläniiton vaikutukset veden laatuun (The Effects on the Quality of Water by Cutting Channels in Reed Beds). Opinnäytetyö (Dissertation), Turku University of Applied Sciences, Fishery and Environmental-Economic Department.
- Kvet 1973. Mineral Nutrients in Shoots of Reed (*Phragmites communis* TRIN) Pol. Arch. Hydrobiol. 20: 137-147.
- Lindholm T. & Frödjö E.M., 1996. Vertical Gradients of a Reed Belt Environment studied by Close-interval Sampling. Arch. Hydrobiol. 137: 177-186
- Maristo L. 1941. Die Seetypen Finnlands auf Floristischer und Vegetationsphysiognomischer Grundlage. Botanical Publications of Finnish Zoological and Botanical Society Vanamo. 15(5). Helsinki. 314 pages.
- Nurminen L. 2003. Role of Macrophytes in a Clay-turbid Lake, Implications of Different Life Forms on Water Quality. Academic dissertation in Limnology. University of Helsinki.
- Ostendorp W. 1989. "Die-back" of reeds in Europe – a critical review of literature. Aquatic Botany 35, 5-26.
- Phillips G.L. 2006. Eutrophication of Shallow Temperate Lakes 261 - 278, publication: The Lakes Handbook vol. 2, Lake Restoration and Rehabilitation, O'Sullivan P.E. & Reynolds C.S. (published by) Blackwell Publishing.
- Pokorny & Kvet 2004. Aquatic Plants and Lake Ecosystems 309-340, in the publication: The Lakes Handbook, O'Sullivan P.E. & Reynolds, C.S. (published by) Blackwell Publishing.
- Poulin B. & Lefebvre G. 2002. Effect of Winter Cutting on the Passerine Breeding Assemblage in French Mediterranean Reedbeds. Biodiversity and Conservation 11: 1567-1581.
- Risgaard-Petersen N. & Jensen K. 1997. Nitrification and Denitrification in the Rhizosphere of the Aquatic Macrophyte *Lobelia Dortmanna* L. Limnology and Oceanography 42: 529-537.
- Rolletschek H., Rolletschek A., Hartendorf T., Kohl J-G., Physiological Consequences of Moving and Burning of *P. Australis* Stands for Rhizome Ventilation and Amino Acid Metabolism, Wetlands Ecology and Management 8: 425-433.
- Sandström, M. 2007. Järviruokovyöhykkeen kyky pidättää ojista tulevaa kuormitusta (Reedbelts ability to retain nutrient of ditches). Opinnäytetyö (Dissertation), Turku University of Applied Sciences.
- Scheffer M., Hosper S.H., Meijer M-L., Moss B., Jeppesen E., 1993. Trends in Ecology and Evolution 8: 275-279.
- Toet S., Bouwman M., Ceva M., & Verhoeven, J.T.A. 2005. Nutrient Removal through Autumn Harvest of *P. Australis* and *Typha Latifolia* Shoots in Relation to Nutrient Loading in a Wetland System Used for Polishing Sewage Treatment Plant Effluent. Journal of Environmental Science and Health Part A 40 (6-7): 1133-1156.
- Toivonen H., & Huttunen P. 1995. Aquatic Macrophytes and Ecological Gradients in 57 Small Lakes in Southern Finland. Aquatic Botany 51: 197-221.
- Uhlenius, N. 1994. Vassbeskränningens inverkan på fosforhalten inom ett avgränsat område. Specialiseringsarbete. Statens fiskeriläroanstalt, institutlinjen.
- Vakkilainen, K. 2005. Submerged Macrophytes Modify Food Web Interactions and Stability of Lake Littoral Ecosystems. Academic dissertation in environmental ecology (2005: 1) Helsingin yliopisto.
- Van der Toorn J. & Mook J.H. 1982. The Influence of Environmental Factors and Management Stands of *Phragmites Australis* I. Effects of Burning, Frost and Insect Damage on Shoot Density and Shoot Size. J. Appl. Ecol 19: 477-499.
- Weisner S.E.B. & Strand J. 2002. 243 Handbook of Lake Restoration, Cambridge University press.
- Van der Putten W.H. 1997. Die-back of *P. Australis* in European Wetlands: An Overview of the European Research Programme on the Reed Die-Back and Progression (1993-1994). Aquat Bot 59: 263-275.





Photo: Finnish native cattle in Hirvensalo, Turku. Outi Tuomela.

A close-up photograph of a small bird, possibly a sparrow or similar, with its beak open as if singing or calling. The bird is positioned in the center-right of the frame, surrounded by vertical reeds. The background is a soft, out-of-focus light blue.

Part III

Voices in the Reed Bed

Reed bed birds

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Reed beds are an important habitat for many bird species. The expansion of reed beds, resulting from eutrophication caused by man's effluent, land uplift and, in part, climate change, has generated new habitats for reed-bed-dependent bird species. The distribution of many types of reed-bed birds has expanded in the course of the last century and the existing species have increased in numbers. In Central Europe, building and the drainage of land for agricultural use has resulted in reed beds becoming more scarce of late. Several Central and Southern European bird species typical of reed beds have almost become extinct. In many countries, such as England and Germany, new reed beds have been planted to protect the threatened bird species of the reed beds.

Reed beds as a nesting habitat

At their best, reed beds are sheltered and nutrient-rich nesting habitats for many bird species. Lush grassy inlets support varied and abundant insect populations and are, therefore, an important breeding ground for many species of fish. At its best, a reed bed includes a variety of structures, interspersed with waterways of different depths. These conditions will guarantee a dense, diverse bird population. If there are extensive coastal meadows connected to the reed beds, the value of the wetlands increases even further. Dabbling Ducks like to feed in coastal meadows, which also attract nesting waders.

Different bird species prefer differently structured reed beds.

Some species, such as the Bittern (*Botaurus stellaris*), require extensive reed beds in order to nest. Studies show that bittern will only nest in a reed bed of more than 20 hectares in size, with an open zone close to the water's edge where the bird can catch fish. The mosaic shape of the reed bed is important for many other bird species, with the majority of birds preferring the edges of the vegetation, such as the borders between the reed bed and open water. Eutrophication reduces the number of birds in an area, and even drives certain species away. Some species, such as the Marsh Harrier (*Circus aeruginosus*) and Bittern like to live in damp and inaccessible parts of the reed bed.



The mosaic shape of reed bed is important for many bird species. Pernaja Gammelbyviken.
Photo: Tero Taponen.

When too much rotting reed material collects at the bottom of the reed bed and the area becomes easy for predatory mammals to access, the birds will find other nesting places. Rails and coots, such as the Water Rail (*Rallus aquaticus*) and Spotted Crake (*Porzana porzana*) respond in a similar way to the drying of reed beds. Reed Buntings (*Emberiza schoeniclus*), on the other hand, can nest even in dry reed beds, but the number of nests would then remain considerably lower than in damp, indented reed beds.

Many bird species nest close to open water at the outer edges of reed beds. Examples of these kinds of birds are Great Crested Grebe (*Podiceps cristatus*), Slavonian Grebe (*Podiceps auritus*) and Coot (*Fulica atra*), which build their low heap-shaped nests of reed at the edge of the reed bed or in a sparse reed bed. If the reed bays have suitable nesting areas, the Black-headed Gull (*Larus ridibundus*), which is relatively new among Finland's bird species, may also set up a nest there. The species experienced dramatic growth in the 1950s, but the numbers have since dropped. Colonies of Black-headed Gulls often nest in eutrophicated wetlands and offer other birds protection against predators. At their best, there may be thousands of pairs of eyes to keep watch for the movements of predators that also threaten the nests of other species nesting amidst their colony, such as Tufted Ducks (*Aythya fuligula*), Common Redshanks (*Tringa totanus*) and many other species. Little Gulls (*Larus minutus*) may settle down to nest amidst colonies of Black-headed Gulls in inland reed bays, but may also form their own nesting colonies. In Finland, this species rarely nests in coastal bays.

When the water level drops and the eutrophication of reed beds reaches a certain point, the number of bird species falls quickly. In extensive homogeneous and paludificated reed beds, the number of species decreases and the most valuable species disappear altogether. The most demanding of the species nesting in reed beds are the Bittern and the Marsh Har-



The Water Rail is rarely seen, but its bellowing, which resembles pig-like squealing, is heard at nights in dense reed beds. Photo: Antti Below.

rier. Of the water birds, the first to disappear are the Diving Ducks. Common Pochards (*Aythya ferina*) and Tufted Ducks can manage in lush shallow waterways, but with the water level decreasing further, they too find other places to nest. Of the Dabbling Ducks, the Mallard and Teal will withstand the closure of open waterways the longest. Teals can sometimes be found in tiny patches of open water in the middle of a reed bed.

The majority of species require an extensive reed bed for nesting. Some species can manage in a more restricted section of the reed bed. Among these species are the Common Reed Bunting and Sedge Warbler (*Acrocephalus schoenobaenus*), which can nest in a shrub outside the reed bed. Among the newcomers of the last century are the Great Reed Warbler (*Acrocephalus arundinaceus*) and Reed Warbler (*Acrocephalus scirpaceus*), which require reed beds that are more extensive and substantial. The Bearded Tit (*Panurus biarmicus*), which landed in Finland some twenty years ago, seems to have settled in extensive reed beds in Finland, but in Central Europe it can nest even in smaller reed beds as long as there are nesting places available. However, in Finland Bearded Tits did not settle in the inland reed beds but instead all the reed beds they use as regular nesting sites are located in coastal bays.



Only in recent decades has the Bearded Tit spread out to nest in the most representative reed bed areas of North Europe. Photo: Antti Below.

Reed beds are also an important habitat for many other newcomers to Finland, such as Little Grebe (*Tachybaptus ruficollis*), Gadwall (*Anas strepera*), Montagu's Harrier (*Circus pygargus*) and Little Crake (*Porzana parva*). Citrine Wagtail (*Motacilla citreola*) nests at the edges of wetland meadows and reed beds, with the nest often found inside the reed bed.

Reed beds as resting areas

Reed bays are significant resting and feeding areas during migration periods. During migration, thousands of water birds can gather in a reed bed on their way to the northern nesting grounds. They either stop in the reed bays to wait for the weather to improve, or to obtain extra nourishment for the next stage of their migratory journey. Most water birds require extensive shallow or semi-shallow open water areas and heterogeneous vegetation. In particular, Dabbling Ducks like to sleep hidden inside the reed bed, whilst Diving Ducks remain in the open water sleeping in a dense flock.

Waders do not like dense reed beds. They are only found in the open fringe areas of reed beds, on shallow sparsely vegetated shores or in coastal meadows. Snipe (*Gallinago gallinago*) is the only wader that may stop in reed beds in greater numbers.

Plenty of Passeriformes rest in reed beds during migratory journeys. The population mainly consists of species nesting in the reed bed, but species living in other types of habitat also

stop by, tempted by the rich nourishment and protection offered by the reed bed. Among the most common visitors are Warblers, such as Willow Warblers (*Phylloscopus trochilus*) and Bluethroats (*Luscinia svecica*).

Reed beds as feeding and moulting areas

Insects and other invertebrates which live in the water and on sea beds or lake bottoms are an important food source for both water birds and waders. In particular, the biomass of mosquito larvae is very large, and similarly the larvae of dragonflies and caddisflies can be very plentiful. Water fleas, which are crustaceans, are an important food source. Water beetles are also suitable food for birds.

In the same way, invertebrates are important food sources for fishes. Without an abundance of invertebrate animals, a substantial bird population could not develop in reed bed areas. Equally important are dragonflies and mosquitoes that have emerged from the water, and similarly many other flying insects are important, especially as food for Passerines.

Reed beds attract plenty of feeders from the surrounding area during nesting times. The reed bed's abundant insect population attracts hundreds of swallows, particularly during periods of bad weather. Even Swifts (*Apus apus*), which more regularly feed in high altitudes, may alight close to a reed bed in search of food during rainy and windy conditions. Northern Hobbies (*Falco subbuteo*), which nest close to the reed bays, can be seen above the reed beds chasing dragonflies during the summer months.

Water birds change all their wing feathers at one time, when they are completely unable to fly for a short time. Lush reed bed areas are important water bird moulting areas because there is abundant food in a small area and the reed bed offers shelter from predators. Several hundreds or even thousands of moulting water birds gather in the best reed bed areas.

Grey Herons (*Ardea cinerea*) from nearby colonies stay at the fringes of the reed bed; they like to fish in the area between the reed bed and the open water. Also feeding on the fish in the reed bay are Ospreys (*Pandion haliaetus*), which can come to fish from some distance away. Common Terns (*Sterna hirundo*) and Arctic Terns (*Sterna paradisaea*), and sometimes even Caspian Terns (*Sterna caspia*), fish in the open sections of the reed beds.

In winter time, many different species feed on the seeds and insects of the reed bed. Blue Tits (*Parus caeruleus*), Bearded Tits and Reed Buntings are some of the most common spe-



cies in the reed bed. The Great Grey Shrike (*Lanius excubitor*) looks for prey from a suitable observation point and the Lesser Spotted Woodpecker (*Dendrocopos minor*) taps for insects that winter inside the reeds.

Protection of reed species

In Finland there are few reed-nesting birds that are under the threat of extinction. Among the threatened species nesting in the rich bird waters of Finland are Moorhen (*Gallinula chloropus*), Black Tern (*Chlidonias niger*), Great Reed Warbler and Black-headed Gull. Of these newcomers, only the Black-headed Gull has decreased in numbers in recent times; the other species are considered threatened because of the small size of their populations.

Annex 1 of the European Birds Directive, which lists the species for which the member countries must allocate specific protection areas, contains more species residing in reed beds. This is largely due to the poor condition of reed beds in southern Europe; the Birds Directive was drafted in 1972 when the EU's member countries only consisted of central and southern

European countries.

Several large reed beds have been included in the international wetlands protection agreement, the so-called RAMSAR agreement. 49 Finnish protection sites have been included in the RAMSAR project, one third of which are coastal bays or lakes that have been overtaken by reed. In Estonia there are 11 RAMSAR sites, including mostly coastal wetlands but also several extensive mire areas.

The Annex of the Birds Directive lists the following as being reed bed species:

Bittern, Black Tern (*Chlidonias niger*), Marsh Harrier, Montagu's Harrier (*Circus pygargus*), Whooper Swan (*Cygnus cygnus*), Bewick's Swan (*Cygnus columbianus*), Crane (*Grus grus*), Little Gull (*Larus minutus*), Bluethroat (*Luscinia svecica*), Smew (*Mergus albellus*), Osprey (*Pandion haliaetus*), Slavonian Grebe (*Podiceps auritus*), Spotted Crane (*Porzana porzana*), Caspian Tern (*Sterna caspia*), Common Tern (*Sterna hirundo*), Arctic Tern (*Sterna paradisaea*) and Wood Sandpiper (*Tringa glareola*).



The Marsh Harrier needs extensive and watery reed beds for nesting. Photo: Antti Below.

The need to maintain and the impacts of maintenance

The number of reed beds has increased, mainly due to eutrophication. They have formed dense reed beds and overtaken previously open coastal meadows. Due to eutrophication the reed beds are drying up and shrubs and trees are beginning to grow. The wetland species are gradually disappearing. Studies have shown that the number of wetland bird species will remain higher in reed beds that are cut regularly than in reed beds that are neglected. Burning a reed bed also has an impact on its structure and, therefore, on its bird population.

The biodiversity of coastal reed beds must be retained in such a way that, as well as maintaining ornithologically important reed beds, coastal meadows and waterways are also kept open. It is possible to utilise a reed bed in a way that also

benefits its bird population. Cutting a reed bed in a stepped fashion in alternate years decreases the amount of plant mass in the area and, therefore, slows down its eutrophication. In order to ensure the diversity of the bird population, it is essential to stop the expansion of the reed beds onto the coastal meadows. On the other hand, cutting the reed beds completely reduces the number of bird species that are dependent on reed beds by preventing them from settling in their usual area in the spring. Even though the reed beds grow back in the summer, the birds will have already moved elsewhere in the remaining reed beds.

Acknowledgement of the structural differences of reed beds in their maintenance brings diversity to bird populations. For instance, the Reed Warbler and Sedge Warbler like tall reed beds, and Bearded Tits prefer tall and thick reed beds. The Reed Bunting likes open aspects, preferring to stay at the edge



After summer cutting of the reed bed, Anseriformes (ducks, geese and swans) and Swallows come to feed almost immediately to the area which has been cut. Photo: Eija Hagelberg.



of reed beds near open water. The Bittern needs watery and shallow edges, and plenty of fish for nourishment. According to studies conducted in England, the size of the reed bed must be, as previously mentioned, a minimum of 20 hectares, of which more than 1/5 must be open water. There must be at least 600 metres of reed bed edge per hectare.

A key for ensuring a healthy bird population is to change uniform reed beds into structurally more diverse reed beds. In assessing the need for maintenance, the presence of threatened and demanding bird species must be considered, so that their habitats are not damaged by the maintenance measures selected. The fringe areas, such as coastal meadows and shrubs, must also be considered when maintaining reed beds; they can be used by reed-based birds for nesting or feeding.

The digging of ponds is an efficient method of increasing the area of open water suitable for water birds. Ponds offer both adults and young birds feeding and moulting areas which are sheltered from predators. The production of water insects in them is high, at least at the start, because the proportion of pondside vegetation is increased. Ponds increase the indented shape and marginal effects of the reed beds, which increases the diversity of the populations of both water birds and other wetland birds. Underwater and floating leafy vegetation develops in ponds.

The mosaic shape of homogenous reed bed areas can also be increased by cutting. A reed bed can be made to regress quite quickly by cutting. Just cutting for two to three years weakens reed beds effectively if the shoots are cut underneath the water surface. The removal of rootstocks combined with cutting substantially improves the effects of maintenance and is a suitable method in places where grazing cannot be used as an effective form of maintenance. The muddy pools preferred by waders are also formed in this way.



Back to the meadow

- restoration of coastal meadows that have been overtaken by reed beds in the Lintulahdet Life project

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Lintulahdet Life (Bird Bays Life) is a wetland restoration project, funded by the EU Life Nature Fund, which included the management of 12 wetlands in Uusimaa and Southwest Finland. These wetlands are located along the Gulf of Finland migratory flyway and are part of the Natura 2000 network (Picture 1). The key aim of the project was to strengthen the importance of the Natura 2000 areas as staging areas, particularly during migratory periods, and to improve the habitats of the wetland species mentioned in the Birds Directive and the Habitats Directive.

In 2003-2007, a total of 160 hectares of paludified coastal meadows were restored by the Lintulahdet Life project. At the start of the project, many of the restoration sites were covered by an almost continuous reed bed and were silted up to a significant degree (Picture 2). In places, the paludification had advanced to such an extent that a lot of willows and deciduous copses had started to grow. In some areas the restoration sites were initially flood-plain reed beds of the *transition mires and quaking bogs biotype*; elsewhere they were *Baltic boreal coastal meadows*. At its best, the vegetation consisted of just a thin strip of low-growing meadow plants at the top of a meadow. In the majority of the restored sites, grazing had stopped decades ago and there were hardly any signs of it in either the vegetation or the flora. Judging by the vegetation and ditches, some of the land had once been cultivated.

Their potential as a staging and nesting area for migratory birds was considered to be the main factor in the selection of restoration sites. The most important selection criteria were the feasibility of opening up a sufficiently extensive open meadow, the survival of meadow species in the area, information about the former grazing history of an area and its location in relation to currently maintained grazing meadows or other open habitats, and the opportunity to mow the meadow all the way to the water's edge. The majority of the chosen



Picture 1. Lintulahdet Life project areas: 1. Saltjärden, Kirkkonummi, 2. Medvastö-Stormossen, Kirkkonummi, 3. Laajalahti, Espoo, 4. Tuusulanjärvi Lake, Tuusula and Järvenpää, 5. Vanhankaupunginlahti Bay, Helsinki, 6. Porvoonjoki River delta, Stensböle, Porvoo, 7. Pernajanlahti Bay, Pernaja, 8. Pyhäjärvi Lake, Iitti, Jaala and Valkeala, 9. Salminlahti Bay, Kotka and Hamina, 10. Kirkkojärvi Lake, Hamina, 11. Pappilansaari-Lupinlahti Bay, Hamina, and 12. Kirkon-Vilkkiläntura, Virolahti.



Picture 2. Before restoration, Maarinniitty meadow in Laajalahti, Espoo, contained a continuous reed bed. Photo: Tero Taponen.



restoration sites are located in coastal bays, approx. 0-40 cm above average sea level, which is why they are, at times, completely covered by water due to the changes in sea level.

The reed beds in the coastal bays of the Gulf of Finland are often very soft, which caused particular challenges for the restoration methods and technologies used. The ground at many of the restoration sites does not, under normal circumstances, support heavy work machinery. Instead, the restoration required special equipment.

Restoration of the coastal meadows - goals

The main goal of the Lintulahdet Life project was to create low-growing coastal meadows in areas where most waders and water birds were suffering from a shortage of suitable habitats, which was caused by paludification, during migration and nesting periods. Another stated goal was to restore a more diverse and representative flora to the reed flood-plains and the near-extinct coastal meadows. Open pools were dug in some of the coastal meadows to provide a breeding ground for insect species that are dependent on wetland conditions, such as the rare Large White-faced Darter (*Leucorrhinia pectoralis*).

Restoration methods

Two main methods are used when restoring coastal meadows that have been overtaken by reeds: reed plants can be crushed with a crusher and the land surface can be rotovated. A normal beam harvester can be used for cutting the reed, but it was found to be badly suited for restoring areas that are in an advanced state of paludification, and too slow for treating extensive areas in difficult conditions. The collection of the harvested reed also proved to be expensive in challenging conditions.

The reed beds tended to be harvested mainly in late summer, in July and August. The reed biomass is then at its largest and the nesting of the reed's bird population is past the most delicate stage. Crush harvesting was also tested in the winter, but the thick layer of snow that accumulated in the reed bed presented a problem; it meant that a long "stubble" was left behind after the cutting. In winter there was no point in crushing the reed. It was better to cut it whole and collect the stems to be used, among other things, as building material.

Crushing a reed bed

The crushing technology involves the use of a crushing blade, which is similar to the blades used for cutting roadsides. The restoration of coastal meadows can be undertaken with a crusher that is fixed to a normal agricultural tractor or, on softer ground, to a lorry that has caterpillar tracks. In drier locations, the use of a tractor may only be possible if double wheels are used. The crusher blade may be fixed to the front of the tractor, or to the back. In the Lintulahdet Life project's restorations, 1.6 m, 2.2 m and 3 m wide crusher blades were used, and they were fixed to the front or back of the tractor. The use of the widest 3-metre crusher blade requires a heavy-duty tractor and is only suitable for hard-bottomed meadows. The narrower 1.6 m and 2.2 m crushers can be used on the front or back of an agricultural tractor and, in the wettest areas, fixed to a lorry that has caterpillar tracks (Pictures 3, 4 and 5).

The crusher is stronger than a beam or plate harvester and, therefore, it is a superior product. Bushes and even individual trees can be cut without breaking the blade. When cutting with traditional beam and plate harvesters, the operator has to avoid individual tall tufts of sedge and other unevenness in the terrain, which means that the stubble will be too long and a part of the meadow will be left uncut. When using traditional methods, the cut material must also be cleared away, which will add to the costs considerably and, in soft locations, is extremely difficult to do with a machine.



Picture 3. The wider 2.2 m crusher attached to the back of a tractor.
Photo: Ilpo Huolman.



Picture 4. A narrow 1.6 m crusher attached to a lorry with caterpillar tracks (Hägglund BV 206). Photo: Ilpo Huolman.

When using a crushing blade, the reed stem is chopped into approximately 10-centimetre-long pieces that are left on the ground. There is currently no way of collecting them effectively. The reed pieces remaining in the meadow probably make the soil slightly more eutrophic, and may even initially accelerate the paludification of the land. Users of this method must be prepared to repeat the cut at the beginning of the treatment for at least 2-3 summers. If grazing animals are allowed in the meadow straight after restoration, there seems to be no need for repeat cutting in the entire area after the first year, although a repeat cut may still be needed close to the water's edge, where grazing may not be possible due to the prevailing conditions. The major benefit of the crush technique is its cost, which is the lowest of all the traditional cutting methods: even extensive meadows can be cut relatively quickly and there are no costs involved in collecting the cuttings. Experience gained during the Lintulahdet Life project would suggest that on a more solid soil, where the crusher can be attached to a tractor, a workman can cut approximately

5-8 ha of meadow per working day. The work is clearly much slower in soft terrains that require special cutting equipment, but even then, several hectares of meadow can be cut per day (Pictures 5 and 6). The negative aspect of the crushing technique is the fact that the cut material is left in the meadow, leading to more eutrophication and faster paludification of the meadow. This technique cannot be recommended as a single measure without planned aftercare that involves either harvesting or grazing. In botanically important sites, the following must be borne in mind: when the sea level rises, the crushed material normally builds up into a thick wall at the tops of the meadows and, therefore, may cover those sections of a meadow that have the most significant vegetation (Picture 7). This problem can be overcome by the development of techniques that would enable the crushed material to be collected by a machine and removed from the site. It should be possible to utilise the crushed material, for instance, as bioenergy.



Picture 5. Equipment on caterpillar tracks can be used to cut meadows even in the softest of terrains. Photo: Ilpo Huolman.



Picture 6. Crushed material forming a thick belt at the tops of meadows in coastal bays. Photo: Ilpo Huolman.

Rotovating surface soil

In restoring coastal meadows to provide a habitat for waders and water birds, it is essential to open a meadow all the way to the water's edge (the so-called blue margin) (Picture 8).

The opening up of the water's edge is usually the most challenging part of meadow maintenance, because the terrain there is usually very soft and maintenance cannot normally be undertaken without special equipment. The need for mechanised maintenance is significant because



Picture 7. In Laajalahti, Espoo, an approximately 50-100-metre-wide belt of the water's edge was rotovated until soft. Photo: Tero Taponen.

grazing animals alone cannot keep the water's edge of the meadow clear, at least at the start of the project.

In the Lintulahdet Life project, two surface soil treatment methods for the opening of the water's edge were tested. In areas that could bear the weight of heavier machinery, the surface soil at the water's edge was loosened with an agricultural rotovator, which is normally used when clearing a forest for fields. The use of a rotovator is limited by the fact that it needs more engine power than a crusher would need, which in turn means that a bigger, heavier tractor is needed. The method has been tried before on hard-bottomed coastal meadows, but this was probably the first time on soft-bottomed flood-plains. Its use in soft-bottomed sites was made possible by the extreme drought of 2006 which, together with the low sea levels, meant that even soft terrains could bear heavier weights than usual. In normal years, the use of heavy machinery would not be possible in most of the coastal bays of the southern coast.

The surface soil is rotovated in order to break the reed rootstocks, which will help to achieve a result that is clearly longer-term than that achieved by ordinary cutting. The rotovator

cuts the rootstocks at a depth of approximately 10-20 centimetres, which is probably enough to impede root growth for several years. In the Lintulahdet Life project, a 4-metre rotavator attached to the trailer of an agricultural tractor was tested. This enabled the operator to rotovate areas at a rate of 0.5 ha/hour. As well as at the water's edge, the rotovator was tested in the indentations in the meadow and at the edges of small ponds. This was done in order to create a small-scale open water's edge more widely in different parts of the meadow.

The other method of creating an open water's edge was to break the surface soil with a machine on caterpillar tracks (Picture 8). This method has previously been used successfully in Sweden, but has probably not been used in Finland before now. The method would seem ideally suited for soft-bottomed sites, where the operators cannot reach the water's edge with heavier machinery. In practice, the surface soil is broken by driving the machine back and forth at the water's edge in a figure-of-eight pattern, when the tracks gradually break the surface of the soil. Reed seems to react readily to even slight breaking of the surface soil.



Picture 8. The rootstock of a reed bed growing at the water's edge can be broken by driving over it with a lorry on caterpillar tracks. The track marks can be seen clearly at the water's edge of the Elfvik meadow in Laajalahti, Espoo. Photo: Tero Taponen.



Key Results

The Lintulahdet Life project was set up to monitor the effects of the restoration of the coastal meadows on both migratory and nesting birds. The effects of the restoration on the habitats and vegetation of the meadows were also monitored, as were its effects on dragonflies, particularly the Large White-faced Darter.

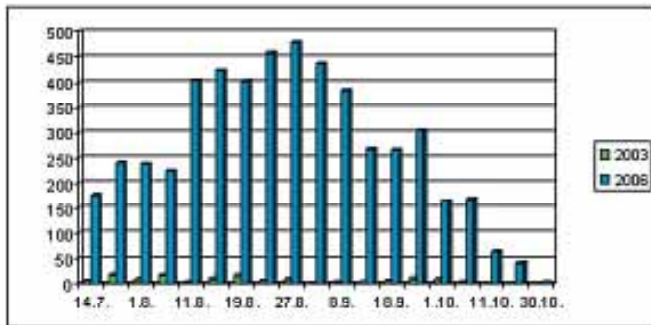
The effects of the restoration of coastal meadows were seen in the bird population soon after the project started. The numbers of waders and water birds multiplied, particularly at the time of migration, when paludificated coastal meadows were once again opened up and access to the water's edge was secured. The Lintulahdet Life project achieved excellent results by restoring meadows that had turned into reed beds. In several sites, the numbers of migratory waders increased significantly as a result of the establishment of managed meadows (Pictures 9 and 10). Before restoration of the coastal bays of the Lintulahdet Life project that had turned into reed beds, only occasional waders ventured into these meadows, but after the restoration, the meadows became an important resting place for several species throughout the migratory period (Picture 11). The restoration of coastal meadows enabled large concentrations of water birds to gather in these meadows. Water birds which regularly feed in these coastal meadows include the dabbling ducks, whose numbers increased tenfold as a result of the restoration (Picture 12). Positive changes have also been observed in the nesting birds; species dependent on coastal meadows that had diminished in numbers, such as the Lapwing, Common Redshank, Meadow Pipit and Yellow Wagtail, have once again become abundant. The species that suffered as a result of the restoration work were the Passeriformes, such as the Sedge Warbler, Reed Warbler and Reed Bunting, whose normal habitats are reed beds. With good planning, habitats can be preserved for these species in most of the sites.

In vegetation, the effects of the restoration of the coastal meadows can be seen early in the gradual decline of reed plants. As a result of cutting, the reed plants initially thin out and stop growing as tall and strong as they used to be. After several annual cuts, gaps start to appear in the reed beds. Reed is removed permanently from a coastal meadow after 5-10 years of active cutting and grazing. It seems that low-growing species gradually spread far into the decaying reed beds, and significant changes were not observed over a monitoring period lasting a few years. A faster impact on vegetation can be

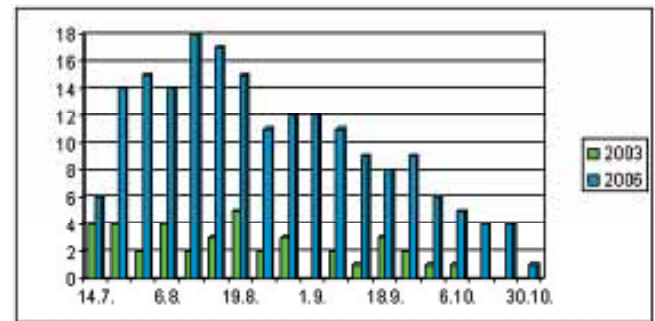
achieved by rotovating the surface of the soil until it is bare, which will remove the reed completely, at least temporarily. In an area in Laajalahti, Espoo, that was rotovated until it was bare, low-growing meadow and shore plants emerged in the summer following the rotovation, such as Celery-leaved Buttercup (*Ranunculus scleratus*), Common Water-plantain (*Alisma plantago-aquatica*), Slender Spike-rush (*Eleocharis uniglumis*) and Marsh Bedstraw (*Galium palustre*). Without continuing maintenance, such as grazing, reed will once again emerge on meadowland, even in sections that were rotovated, and reclaim its position fairly quickly.

The pools that were dug for the dragonflies proved to be a good method of maintaining their habitat. The small pools in reed beds offer a good habitat, for instance, for the breeding of adult Large White-faced Darters, and excellent protection against predatory fish for their larvae (Picture 13). In sites that had an existing population of Large White-faced Darters, the colonisation of new pools took place fairly swiftly.

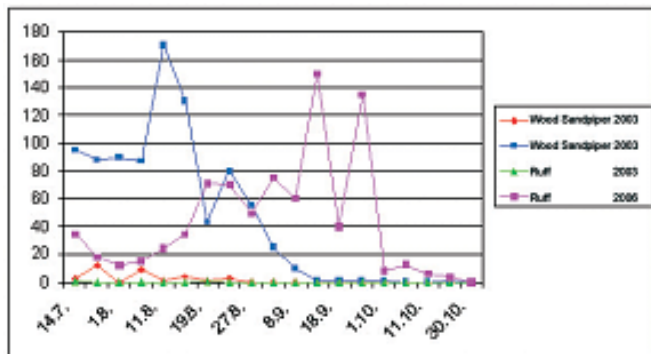




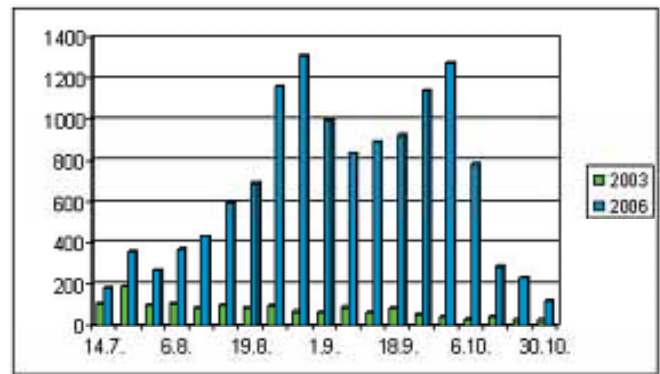
Picture 9. The number of waders in Laajalahti, Espoo, in autumn 2003 and autumn 2006. Since the coastal meadows were restored, the number of waders has multiplied several times and the area has been visited by several scarce bird species, such as Black-tailed Godwit (*Limosa limosa*), Bar-tailed Godwit (*Limosa lapponica*), Marsh Sandpiper (*Tringa stagnatilis*), Red-necked Phalarope (*Phalaropus lobatus*), Broad-billed Sandpiper (*Limicola falcinellus*) and Knot (*Calidris canutus*).



Picture 10. The number of waders in Laajalahti, Espoo, before the establishment of managed meadows in 2003, and since they were established in 2006. Due to the managed meadows, the number of waders in Laajalahti has multiplied and several wader species visit the area.



Picture 11. The Lintulahdet Life project focused on the species in the Birds Directive Annex I, Wood Sandpiper (*Tringa glareola*) and Ruff (*Philomachus pugnax*), for which resting areas have been established for the migration periods. In Laajalahti, Espoo, the number of both these species grew sharply due to the restoration of the coastal meadows. Before the restoration in 2003, both species only visited Laajalahti occasionally, but the bird count in 2006 showed that the area has become an important resting area for Wood Sandpiper and Ruff, particularly in the autumn migration period.



Picture 12. Since the restoration of coastal meadows, Laajalahti in Espoo has become one of the most important resting areas for dabbling ducks on Finland's south coast. For Gadwall (*Anas strepera*), Laajalahti is probably the most important collection point on the south coast.



Picture 13. At Lake Pyhäjärvi, Iitti, a group of small pools was dug to provide a breeding ground for the Large White-faced Darter. Photo: Tero Taponen.

Reed bed biodiversity

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The number of species present is a fundamental property of all habitats and ecosystems. Diversity and its implications for ecological processes and ecosystem functions have therefore received attention from biologists for a long time (Pielou, 1975, Wilson, 1988, Tilman, 1999 and Verhoeven, et al. 2006). In recent years, after the UN Conference on Environment and Development in Rio de Janeiro 1992, the preservation of biodiversity has been raised to an issue of global concern.

The term biodiversity can be defined as the variation of life at all levels of biological organization including individuals, populations and communities. Usually it refers to the number of species within a specified ecological community, such as reed beds, or in a geographical area. Species pool is often used

synonymously with biodiversity. A huge variety of species of microbes, plants, invertebrates, fish, amphibians, reptiles, birds and mammals can be part of an ecological community. For practical reasons, in research only certain groups of species, such as plants or birds, are sampled and analyzed at the same time. The number of species occurring in a sample from a local reed bed, or any local biological community, is called species richness or species density. Often diversity is used synonymously. More precisely, diversity includes the relative abundance of species taking into account not only the number of species but also the number of individuals per species. Genetic diversity is another aspect of biodiversity. It refers to the variation of genes that are represented among



Painting: Elen Apsalon.



individuals of a species.

Before we start to discuss the biodiversity of reed beds we should note that 'reed bed' is not a strictly defined biological community. The term may not have the same meaning for different users. In a wide sense, reed beds include all stands of tall, grass-like emergent vegetation in shallow water, including Common Reed (*Phragmites australis*), Bulrushes (*Typha spp.*), Reed Sweet-grass (*Glyceria maxima*) and Common Club-rush (*Schoenoplectus lacustris*) in northern Europe (Ekstam, et al 1992). More restricted, reed beds refer to vegetation-types that are dominated by *Phragmites australis*. It is in the latter, more restricted, sense the term will be used in this chapter.

The opinion among biologists and landscape managers with respect to the value of reed beds for biodiversity differs (e.g. Ailstock et al 2001, Silliman & Bertness, 2004, Brix 1999 and Graveland 1998). At a distance, reed beds do not appear to be particularly important for biodiversity. Typically, one single plants species dominate large areas of shallow waters completely. Not surprisingly, the invasive and dominant characters of *Phragmites* populations are considered to be a problem for maintenance of plant species richness in wetlands. Therefore, several methods have been developed for controlling this species, including biological, hydrological, chemical and mechanical procedures. On the other hand, a habitat with few species of vascular plants does not necessarily imply few species of other organisms. Plant species richness may simply be a poor predictor of the habitat species pool, the total number of species that occur in the reed beds of a region. Further, a species-poor habitat may be inhabited by regionally rare species that are restricted to the habitat during parts of the life cycle. Control measures of such habitats may therefore result in a decline of rare populations at a regional scale. If an increase of local diversity is achieved by colonization of regionally common species, at the expense of local extinction of rare ones, then the conservationists have won a Pyrrhic victory.

In this chapter we will have a closer look on various aspects of biodiversity of reed beds. We begin with an overview of the genetic diversity of the *Phragmites* populations and continue with the species richness of plants, invertebrates and birds in reed beds.

Genetic diversity of Phragmites australis

Phragmites australis is the most successful and widespread of the four species that are identified in its genus (Clayton 1967 and Björk 1967). Further, it is the only *Phragmites* species

found in Europe. Within the species, large variation with respect to shoot morphology and density occur. These variations are caused by both genetic and environmental factors.

One apparent genetic difference is the variation in chromosome numbers caused by chromosome doubling, so-called ploidy levels (Clevering & Lissner 1999). The most common ploidy level in the Baltic region appears to have four complete sets of chromosomes in the nuclei (4x, tetraploids). It has most likely originated from hybridization (genetic mix) of two diploid ancestral populations (2x, x=12). The ancestral populations are probably extinct, out-competed by the more vigorously growing tetraploid hybrids. The range of ploidy levels found around the Baltic Sea spans from triploids to octoploids (3x-4x-6x-8x) (Clevering & Lissner 1999). Although the ploidy level can explain some variation, it is not that simple that chromosome doubling always results in taller and larger plants.

Contrary to common belief, genetically different clones cannot easily be identified by morphological differences. Molecular methods have revealed that morphologically similar reed beds might be polyclonal, i.e. originate from genetically different, sexually produced seeds (Koppitz et al. 1997 and Koppitz 1999). Further, different clones may intermingle or co-exist next to each other in one reed bed. At other sites, one single clone may cover several thousand square meters.

Recruitment from seeds contributes to the preservation of genetic diversity. Pollination experiments show that the flowers are, at least partially, self-incompatible. This means that a clone is more or less unable to fertilize itself. Therefore, each seed have a unique combination of genes (Björk 1967 and Ishii & Kadono 2002). However, due to large clone size, seed set in monoclonal reed beds is likely to be limited by shortage of compatible pollen. This, as we shall see later, is an important reed bed quality aspect for seedeaters such as birds.

Larger clonal diversity is shown to occur at the landside compared to the lakeside part of the reed bed. This is an expected pattern, because colonization of seedlings only occurs on moist soils, on exposed lake sediments during drought situations, or in the upper littoral (Ekstam & Weiner 1991 and Amsberry et al. 2000). Seeds are simply not able to grow and establish when submerged in water. After episodes of recruitment, selection for, and local adaption to deep water may occur. Seeds of both tetraploids and octoploids are both highly germinable. The requirements of the seeds restrict germination to gaps on soils exposed to air (Ekstam et al. 1999 and Ekstam & Forseby 1999).

Plant species richness

Reed beds dominated by *Phragmites* are poor habitats for other plant species. Species richness in the vegetation appears to be inversely related to the degree of dominance by reed (Wheeler & Giller 1982 and Wheeler & Shaw 1991). Further, the number of rare fen plant species is shown to decrease with increasing cover of *Phragmites*. This phenomenon is not specific to dominance of *Phragmites*. It is a general pattern for tall and competitive plant species at nutrient rich sites. At high productivity or small losses of biomass, one or a few plant species are able to absorb the light resources and thereby competitively exclude other plants. The canopy of *Phragmites* can greatly reduce the availability of light in a reed bed (Fig. 1). In dense stands, the light penetration to the water-surface can be less than 5% of incident light on the stand (Ekstam et al. 1985a). Only a few shade tolerant species, like *Utricularia vulgaris*, are able to persist in such low light levels. Other reed bed herbs like *Cicuta virosa*, *Sium latifolium*, *Ranunculus lin-*

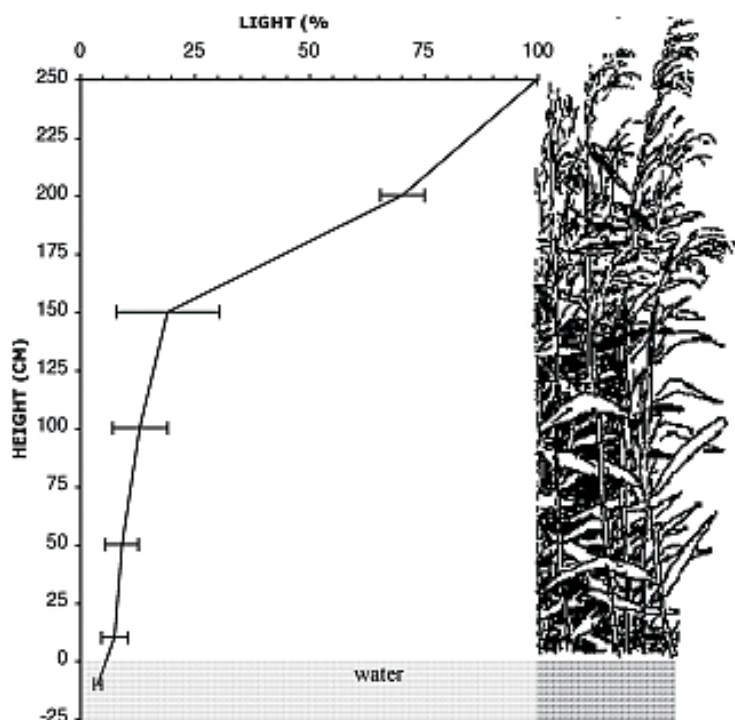


Fig. 1. Light profile in a dense reed bed during July (% of photosynthetically active radiation above the reed canopy. Redrawn from Ekstam et al. 1985a.

gua, *Lycopus europaeus* and *Carex pseudocyperus* occur in gaps and along the edges of dense reed stands. This is one of the reasons why length of edges is a quality aspect, affecting the local biodiversity of a reed bed.

No matter if light availability is low, biofilms of photosynthetic micro-algae and other microbes are always present in the water. The microbial biofilms cover all surfaces of stems and plant litter. The diversity of microbial life forms contributes to an array of important ecological processes, such as decomposition of organic matter and retention of nutrients (filtering effects). The microbial species pool in reed beds is not well known. Most of the micro-algae in the reed beds are epiphytic. The epiphytes primarily include a variety of diatoms enclosed in spectacular walls of silica (Fig. 2). The biomass of planktonic forms is small compared to the biofilms (Ekstam et al. 1985a and Riber et al. 1984), which provide important nutrient resources for grazing invertebrates and the littoral food chain.

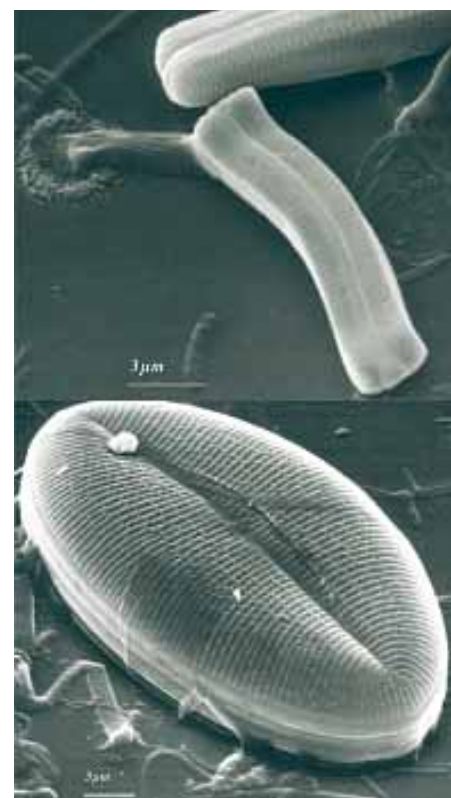


Fig. 2. SEM pictures of two epiphytic diatoms, *Achnanthes* sp. (above) and *Cocconeis placentula* (below). Photo: Author.

Many aquatic invertebrates...

In general, plant material is poor quality food. The tissues of *Phragmites* are no exception. For herbivores and detritivores, the carbon to nitrogen ratio is far from being nutritionally balanced. It contains too much of carbon in durable cellulose, and shortage of nitrogenous proteins. In addition, shoots of *Phragmites* are mechanically supported and protected by silicate in the epidermal tissue (Lau et al. 1978). Consequently, the dead stems are not favoured food by detritivorous invertebrates such as *Asellus aquaticus*. This, in turn, is probably the main reason why the decomposition rates are exceedingly slow. Experiments suggest that in Nordic climates decomposition rates of *Phragmites* stems, measured as the time for 50 percent loss of dry weight, range between 1-3 years (Ekstam et al. 1985a and Andersen 1978).

Persistent litter, small biomass of planktonic algae and light limited productivity of the epiphytic algae do not appear to provide the best support for species rich macro-invertebrate communities.

Nevertheless, there are many types of aquatic invertebrates found in reed beds (Williams & Feltmate 1992). Many are actively moving around foraging and have a large body size. Both the number of individuals and the species richness are astonishing (Fig. 3 & 4). Some abundant and actively foraging groups are the larvae of the phantom midge (*Chaoborus spp.*), crustaceans (ostracods and *Asellus aquaticus*) and the aquatic heteroptera (*Notonecta spp.* and corixids). Aquatic beetles (*Coleoptera*) are both represented by many species and by many individuals (Ekstam et al. 1985b).

Why then, are reed habitats so favourable for free-living macro-invertebrates? Food resources are not the only factor determining the distribution of species. Another factor is the permanence of the habitat. For reed beds this invokes the hydroperiod. Large invertebrates usually have a larval stage, and a life cycle that is longer than one year. Not all of them are able to migrate or survive during a drought. Reed beds standing in water are therefore preferred habitats for long-lived macro-invertebrates. The distribution of vertebrate predators is also important (Wellborn et al. 1996). Fish, especially

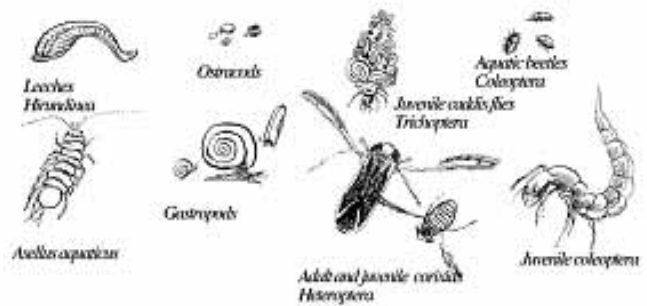
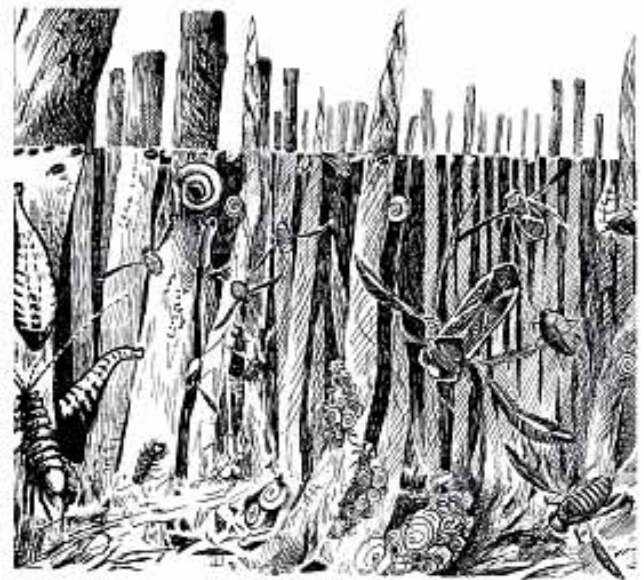


Fig. 3. Aquatic invertebrates in a reed bed. Ill. Gunnar Björkman.

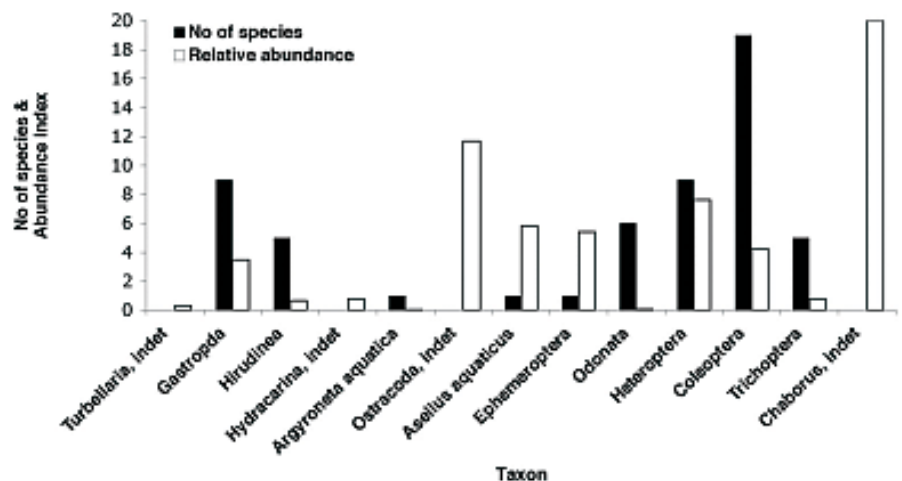


Fig. 4. Number of species (black bars) and a relative abundance index (white bars) of aquatic invertebrate taxa in a reedstand of Lake Tåkern, Sweden. Redrawn from Ekstam et al. 1985b.

cyprinids, are efficient predators that are able to reduce the abundance of large and actively foraging invertebrates (Andersson 1981, Hargerby et al. 1994 and Wagner & Hansson 1998). The main reason for this is that most fish grow large compared to their invertebrate prey. The prey is neither large nor fast enough to avoid predation. Further, when different prey sizes are available, the fish selects large prey that is easy to catch and to handle. In a reed bed, the spatial structure of stems and litter make it impossible for larger fishes to find and catch the large prey items. Therefore, the reed bed function as a predator free refuge for macro-invertebrates in waterbodies inhabited by fish. This is also of importance for the birds that are competitors with fish. But before we go into the realm of the birds we must have a look on the invertebrates in the reed itself.

... and fewer but more unique 'aerial' invertebrates

In comparison with other grasses, *Phragmites* supports many insect species (Tscharncke 1999 and 1992). At least 26 plant eating invertebrate species have been identified as monophagous on *Phragmites*, i.e. completely dependent on this species. Some are stem-borers whose larvae eat plant material inside the shoot. One of them, the moth *Archana gemipunctata*, functions as a keystone species that affects both the structure of the reed bed and the composition of the insect community.

The larvae of *A. gemipunctata* kills the main shoot during its feeding downwards in the stem (van der Toorn & Mook 1982). The damage breaks the apical dominance of the main shoot and initiates growth of side-shoots beneath the lowest damaged node. When the larvae have eaten out a few internodes from the inside, it moves to a new main shoot where it resumes feeding downwards from the highest internode. The larvae need about three shoots to pupate and overwinter inside a stem of a main shoot. During larvae outbreaks, nearly all main shoots can be damaged and replaced by a lot of thin side-shoots. The side-shoots are not large enough for feeding. Therefore, overexploitation of shoots results in mortality among the larvae.

Several insect species take advantage of this process. Some species live between the wilting leaves of the damaged shoots. A second group attack the newly produced side-shoots. Saprophagous insects feeding on the droppings from *Archana*, constitutes a third group. And finally, bees and wasps build nests in the broken shoots.

Finally we should pay attention to an aphid, *Hyalopterus prunii* that invades the reed bed during the summer. The main hosts are trees of *Prunus*, plum trees etc. The occurrences in the reed bed coincide with a period of intensive foraging of young and pre-migrating warblers. Again, edges of the habitat appear to be important. Shoots are more frequently attacked by the aphids at the edges than inside the reed bed (Tscharncke 1992).

Five exclusive reed bird species

Habitat quality for invertebrate communities in reed beds is critically related to the presence of old standing stems. Management by mowing or burning reduce over-wintering animal populations on or inside the reed. Unfortunately, this also affects birds in the reed bed (Nilsson et al. 1988). From a bird point of view, the reed bed is a nesting and foraging site, endowed with useful building material and food resources for both breeding and non-breeding species. The best support for nest constructions is provided by the reed with standing dead stems from previous years. The old reed is used by birds to place nests above the highest water level. Further, the dense shoot structure offers protection against both predators and severe environmental conditions during all phases of the life cycle. Starlings (*Sturnus vulgaris*) and a few other species, use reed beds primarily as roosting sites during migration. In the winter, terrestrial passerines feed on over-wintering insects in reed beds. The winter inhabitants include Blue Tit, Redpoll and Wren (*Parus caeruleus*, *Acanthis flammea*, *Troglodytes troglodytes*). Additionally, autumn and winter roosters attract birds of prey such as Merlin, Hen Harrier and Sparrowhawk (*Falco columbarius*, *Circus cyaneus*, *Accipiter nisus*).

During the breeding season, the protective function appears to be more important than the provision of food for most of the bird species (Fig. 5). In northern Europe, a core group of five species are completely dependent on the reed beds for both nesting and foraging, i.e. bittern, Bearded Tit, Reed Warbler, Great Reed Warbler and Water Rail (*Botaurus stellaris*, *Panurus biarmicus*, *Acrocephalus scirpaceus*, *A. arundinaceus*, *Rallus aquaticus*). The Bearded Tit, may remain in the same reed bed during its entire life. This is made possible by a seasonal shift of food source, from feeding on invertebrates in spring and summer to a seed diet in winter. The other four species migrate away from the reed beds before winter and freezing results in poor availability of food.

Water Rail, Bittern and the waterfowls find all their food

in the water. But aquatic insects are also an important and easily available food source when the juvenile stages emerge as adults above the water. Indeed, field studies support the importance of hydroperiod and food availability for overall abundance of passerines (Poulin et al. 2002). In conclusion, both the abundance and diversity of bird species can be expected to be highest at the edges of flooded reed beds. Especially edges towards open water.

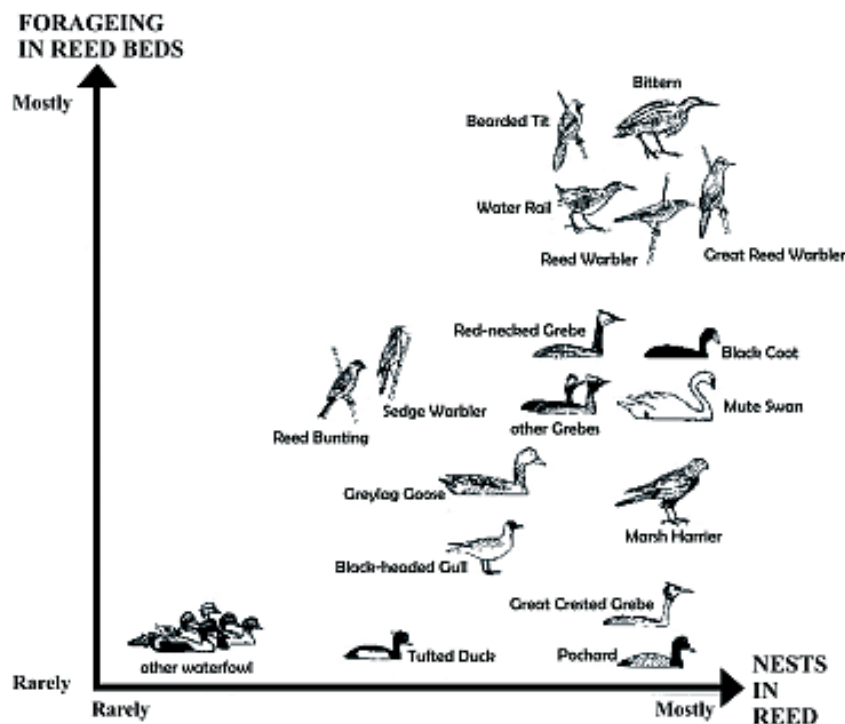


Fig. 5. Usage of reed beds by bird species. Ill. Nils Forshed.

References

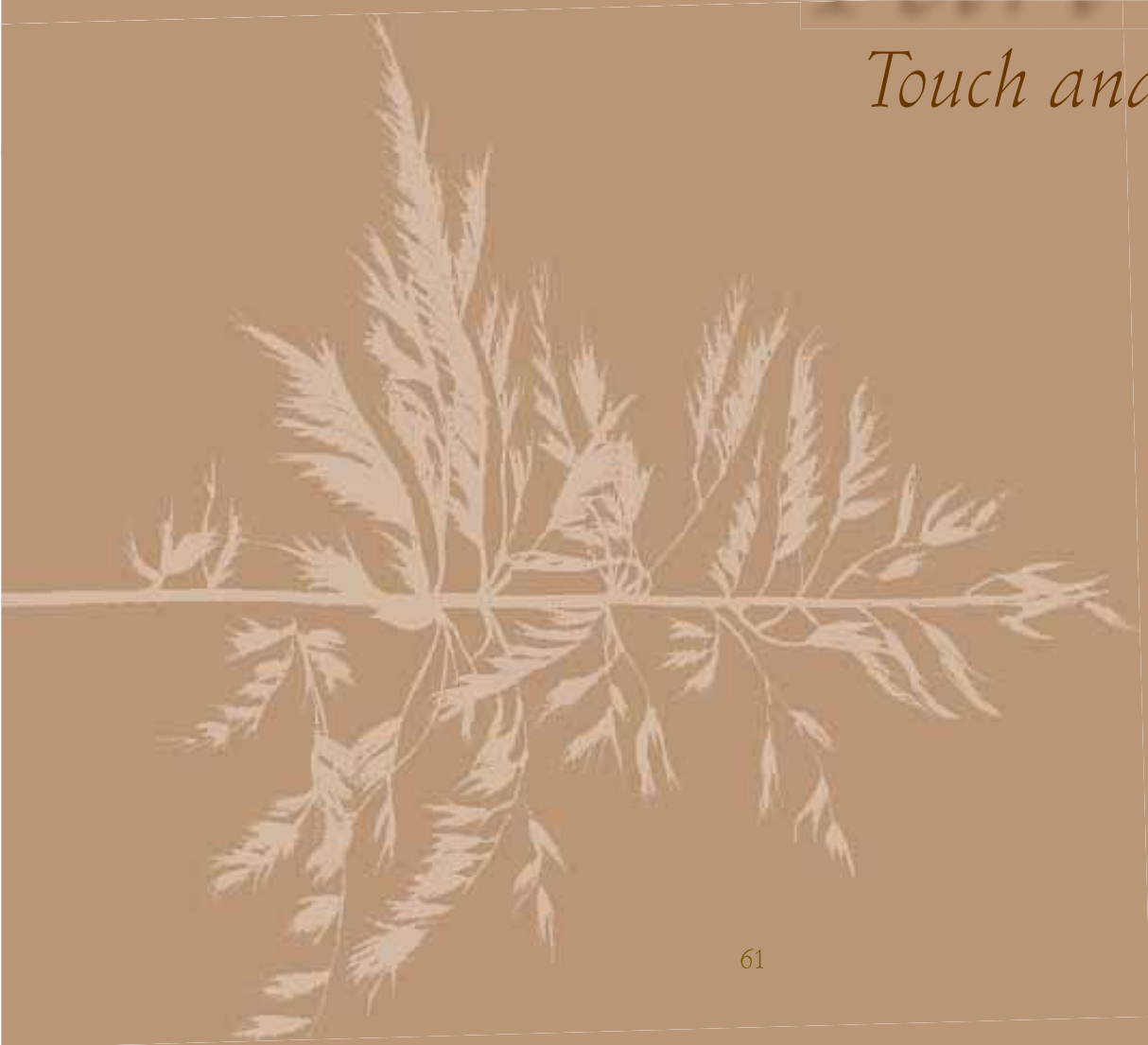
- Ailstock, M.S., Norman, C.M. & Bushmann, P.J. 2001. Common Reed *Phragmites australis*: Control and effects upon biodiversity in freshwater nontidal wetlands. *Restoration Ecology*, 9(1): p. 49-59.
- Amsberry, L. et al. 2000. Clonal integration and the expansion of *Phragmites australis*. *Ecological Applications*, 10(4): p. 1110-1118.
- Andersen, F.O. 1978. Effects of nutrient level on the decomposition of *Phragmites communis* Trin. *Archiv für Hydrobiologie*, 84: p. 42-54.
- Andersson, G. 1981. Fiskars inverkan på sjöfågel och fågelsjöar. *Anser*, 20: p. 21-34.
- Björk, S. 1967. Ecological investigations of *Phragmites communis*. *Folia Limnologica Scandinavica*, Vol. 14. 248.
- Brix, H. 1999. The European research project on reed die-back and progression (EUREED). *Limnologia*, 29(1): p. 5-10.
- Clayton, W.D. 1967. Studies in the Graminae: XIV. *Kew Bull*, 21: p. 113-117.
- Clevering, O.A. & Lissner, J. 1999. Taxonomy, chromosome numbers, clonal diversity and population dynamics of *Phragmites australis*. *Aquatic-Botany*, 64(3-4): p. 185-208.
- Ekstam, B., Bengtsson, T. & Landin, J. 1985a. Konsekvenser för vattenlevande organismer av vasskörd vintertid i sjön Tåkern, in *Naturvårdsverket Rapport*. Statens Naturvårdsverk: Stockholm. p. 111pp.
- Ekstam, B. & Forseby, Å. 1999. Germination response of *Phragmites australis* and *Typha latifolia* to diurnal fluctuations in temperature. *Seed Science Research*, 9: p. 157-163.
- Ekstam, B., Granéli, W. & Weisner, S.E.B. 1992. Establishment of reedbeds, in Ward, D. (Ed.). *Reedbeds for wildlife*. The Royal Society for Protection of Birds/ University of Bristol. p. 3-19.
- Ekstam, B., Johannesson, R. & Milberg, P. 1999. The effect of light and number of diurnal temperature fluctuations on germination of *Phragmites australis*. *Seed Science Research*, 9: p. 165-170.
- Ekstam, B., Landin, J. & Bengtsson, T. 1985b. Effekter av vasskörd i sjön Tåkern, in Sjöberg, K. (Ed.). *Våtmarkerna och fågelfaunan*. Sveriges ornitologiska förening: Stockholm. p. 47-52.
- Ekstam, B. & Weisner, S.E.B. 1991. Dynamics of emergent vegetation in relation to open water of shallow lakes, in M. Finlayson & Larsson, T. (Ed.). *Wetland management and restoration*.

- Swedish Environmental Protection Agency: Solna, Sweden. p. 56-64.
- Graveland, J. 1998. Reed die-back, water level management and the decline of the Great Reed Warbler *Acrocephalus arundinaceus* in the Netherlands. *Ardea*, 86(2): p. 187-201.
- Hargeby, A., et al. 1994. Trophic web structure in a shallow lake during a dominance shift from phytoplankton to submerged macrophytes. *Hydrobiologia*, 279/280: p. 83-90.
- Ishii, J. & Kadono, Y. 2002. Factors influencing seed production of *Phragmites australis*. *Aquatic Botany*, 72(2): p. 129-141.
- Koppitz, H. 1999. Analysis of genetic diversity among selected populations of *Phragmites australis* world-wide. *Aquatic-Botany*. 64(3-4): p. 209-221.
- Koppitz, H., et al. 1997. Some aspects of the importance of genetic diversity in *Phragmites australis* (Cav.) Trin. ex Steudel for the development of reed stands. *Botanica Acta*, 110(3): p. 217-223.
- Lau, E., et al., 1978. Structure and localisation of silica in the leaf and internodal epidermal system of the marsh grass *Phragmites australis*. *Canadian Journal of Botany*, 56: p. 1696-1701.
- Nilsson, L., Nilsson, P. & Sandberg, H. 1988. Effekter av vasskörd på den häckande fågelfaunan i Tåkern. *Vår Fågelvärld*, 47: p. 310-319.
- Pielou, E.C. 1975. *Ecological Diversity*. John Wiley, New York.
- Poulin, B., Lefebvre, G. & Mauchamp, A. 2002. Habitat requirements and reed bed management in southern France. *Biological Conservation*. 107: p. 315-325
- Riber, H.H., Sørensen, J.P. & Schierup, H.H. 1984. Primary productivity and biomass of epiphytes on *Phragmites australis* (Cav.) Trin ex Steudel in a eutrophic Danish lake. *Holarctic Ecology*.
- Silliman, B.R. & Bertness, M.D. 2004. Shoreline Development Drives Invasion of *Phragmites australis* and the Loss of Plant Diversity on New England Salt Marshes. *Conservation Biology*. 18(5): p. 1424-1434.
- Tilman, D. 1999. Ecology - Diversity and production in European grasslands. *Science* 286(5442): p. 1099-1100.
- Tscharntke, T. 1992. Fragmentation of *Phragmites* habitats, minimum viable population size, habitat suitability, and local extinction of moths, midges, flies, aphids, and birds. *Conservation Biology*, 6(4): p. 530-536.
- Tscharntke, T. 1999. Insects on Common Reed (*Phragmites australis*): community structure and the impact of herbivory on shoot growth. *Aquatic Botany*, 64: p. 399-410.
- van der Toorn, J. & Mook, J.H. 1982. The influence of environmental factors and management on stands of *Phragmites australis*. 1. Effects of burning, frost and insect damage on shoot density and shoot size. *J. Appl. Ecol.*, 19: p. 477-499.
- Verhoeven, J.T.A. et al. 2006. Regional and global concerns over wetlands and water quality. *Trends in Ecology & Evolution*, 21(2): p. 96-103.
- Wagner, B.M.A. & Hansson, L.-A. 1998. Food competition and niche separation between fish and the Red-necked Grebe *Podiceps grisegena* (Boddaert, 1783). *Hydrobiologia*, 368: p. 75-81.
- Wellborn, G.A., Skelly, D.K. & Werner, E.E. 1996. Mechanisms creating community structure across a freshwater habitat gradient. *Annual Review of Ecology and Systematics*, 27: p. 337-363.
- Wheeler, B.D. & Giller, K.E. 1982. Species richness of herbaceous fen vegetation in Broadland, Norfolk in relation to the quantity of above-ground plant material. *Journal of Ecology*, 70: p. 179-200.
- Wheeler, B.D. & Shaw, S.C. 1991. Above-ground crop mass and species richness of the principal types of herbaceous rich fen vegetation of lowland England and Wales. *Journal of Ecology*, 79: p. 285-301.
- Williams, D.D. & Feltmate, B.W. 1992. *Aquatic insects*. Oxford, UK: CAB International.
- Wilson, E.O. 1988. *Biodiversity*. National Academy Press. Washington.



Part IV

Touch and Thatch



Traditional use of reed

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The reed pen has had a central part to play in writing, and thereby the development of society and trade. In 2800-2700 BC, the picture writing of Egyptians and Sumerians evolved into a sign-based writing, which the Egyptians wrote with a reed pen and ink on papyrus. The Sumerians used a split reed and a damp clay tablet. With the use of these methods, the collection and relaying of information, for instance regarding taxes or traded goods and payments, became easier compared to previous picture writing carved in stone.

Pan's pipes is an ancient instrument used by primitive peoples, which is made of reed pipes tied together with wax. The Greek syrinx pipe received its name from an ancient Greek legend. Syrinx was a mermaid who was chased by Pan, who was enamoured of her. She sought refuge in the Lado river, where she turned into a reed. When a gust of wind blew through the reed bed, the reed produced a faint sound. Pan fell in love with the sound and built an instrument out of reed that he named Syrinx.

The reed pen and Pan's pipes are probably the best known objects made out of Common Reed. Traditional uses of Common Reed and the opportunities for its utilisation are little known these days. This article deals with traditional uses of Common Reed, which have been all but forgotten, its significance in Southern Finland, and the ways of utilising Common Reed in the 21st century. Southern Finland here means the Finnish provinces on the northern shores of the Gulf of Finland.

Common Reed as a useful plant

It is thought that Common Reed was utilised in the Gulf of Finland area as early as prehistoric times. Habitation in the Stone Age was situated along waterways and people were hunter-gatherers, who also fished. Stone Age man may have covered his abode with reed, ate its rootstocks and made reed whistles and pipes to alert each other, to lure birds and to



A prehistoric reed-covered dwelling may have looked like this. Kuralan Kylämäki provincial museum in Turku, Finland. Photo: Martti Nakari.

play music with. Agriculture and animal husbandry started to spread in the area at the start of the Bronze Age in approximately 1500-1300 BC. Water plants, such as Common Reed, were probably used as a natural source of fodder for the populations living along the region's waterways.

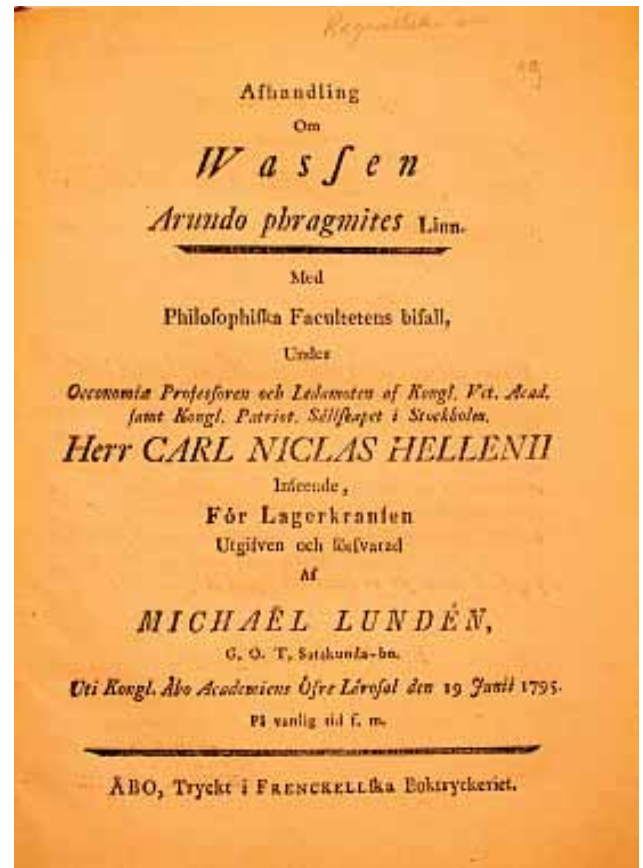
At the start of Finland's Medieval period, between the 12th and 13th centuries, agriculture, i.e. grain production and animal husbandry, had become the most important livelihood. Animal husbandry was an integral part of ancient agriculture: the continuous growing of crops demanded regular fertilisation. Information about the populations and their livelihoods has survived thanks to a system of church taxation. This data also gives us clues about the utilisation of Common Reed. Since the early Middle Ages, parishioners of the parish of Turku had to pay their vicar tax in the form of food items, which were called "extra rations". In the old Finnish villages of Southwest Finland, at the end of the 13th century this tax was paid in the form of cereals. The Swedish immigrants and Finnish pioneers of the archipelago and coastal areas paid their taxes in the form of butter. They therefore had to produce butter in excess of their own needs, which required a sizeable number of cattle to be raised.

Fodder for the cattle was collected from nature, and these pioneers more than likely collected their fodder on the coastal meadows and in reed beds. This assumption is confirmed by the information known about the use and collection rights of Common Reed. In 15th century land and provincial legislation, they were likened to the "enjoyment of fields, meadows and domestic forests" and disputes were heard by local magistrates' courts. This would indicate that reed was already an important commodity in those early days. As well as being used as fodder for cattle, the use of Common Reed flowers to stuff mattresses and pillows started in the Middle Ages. Straw has been used as a roofing material since the 17th century. The use of thatched roofs on domestic buildings spread from Sweden. In Southwest Finland, where there was not enough rye straw to be had, people used reed as roofing material.

Towards the end of the 18th century, Europe experienced great enthusiasm for agriculture and the promotion of country life. According to this way of thinking, called physiocracy ("the power of nature"), soil and water are the only sources of riches and consequently only agriculture (plus mining and fishing) can increase a society's wealth. Under the Swedish rule in Finland, this period was called "the era of utilitarianism".

For example in 1777, the "Economic Paper of the Patriotic Association", published in Stockholm, described the useful-

ness of Common Reed as follows: "*Common Reed, which is used by bricklayers on gypsum roofs, by weavers as bobbin pipes and by artilleries as ignition pipes, is a very useful plant indeed. As it is more durable than straw, it is also used for thatching and, as cattle like to eat it, it is particularly useful for the farmer.*"



Inner cover page of Michael Lunden's thesis "Om Wassen" in 1795.

The same era also saw the doctoral thesis of Michael Lunden entitled "Om Wassen" (About Reed) at Åbo Academy in 1795. In his thesis, Lunden writes that Common Reed is excellent fodder, roofing material ("it beats rye straw without question due to its excellent properties"), mats made of reed are used to protect young plants from excessive sun and from the "extreme harshness of the Nordic weather". He goes on to say that reed is a "safe and useful tool for fixing gypsum" when plastering ceilings. The reed stems have been used as bobbin pipes in weaving. The soft flower tufts "are used among the

least wealthy of our nation, considering their relative softness, as filling in bed-linen and mattresses". The flowers could also be used to dye woollen cloth green, and bunches of the end tufts would be ideal for "dusting furniture and other domestic appliances of value". The rootstalks were used to treat many illnesses and complaints in folk medicine. According to Lunden, "As Common Reed serves us so well in our households, it is only natural that we need to discover and learn the best ways to take care of it in our waterways and reservoirs". He also gives advice on how reed beds are cared for and reeds are planted.

Common Reed was, therefore, utilised in numerous ways in the 18th and 19th centuries. Reed was important fodder for cattle, and the flower tufts were used to stuff mattresses and pillows. The tufts were then an important commodity. Due to the unavailability of other roofing materials, or the difficulty of sourcing them, Common Reed was widely used for thatching in the coastal areas of Southwest Finland and the archipelago.

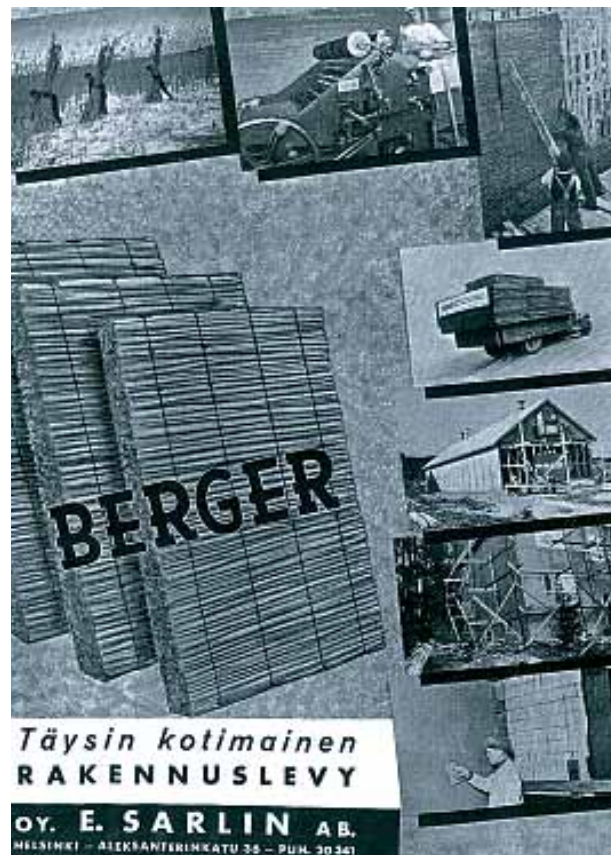
After the 1870s, the focus of Finland's agriculture started to shift from crop growing to dairy farming. The reasons for this were the famine of the late 1860s (which led to the realisation that traditional farming methods were insufficient to feed the growing population) and the fact that it was unprofitable to grow grain for bread-making, whereas the price of butter had grown thanks to the increased exports of butter. The change in agriculture was, of course, influenced by the structural change that took place when the previously self-sufficient society became a barter economy.

In agriculture, new farming methods were introduced and the wealthiest farmers started to mechanise their farms. The most important agricultural change was the introduction of arable cultivation of hay. The growing number of dairy cattle needed more fodder of a better quality during the winter in order to go on producing milk throughout the year. With the expansion of arable cultivation, the use of Common Reed as fodder decreased, particularly on farms. This meant that farmers on smallholdings, and the landless, had easier access to reed beds to obtain fodder for their animals.

Mechanisation also promoted the use of Common Reed over rye straw as a thatching material; due to the mechanised harvesting of rye, rye straw was no longer available for thatching. This meant that rye straw was replaced by Common Reed. The invention of the shingle plane at that time meant that shingles also gained popularity as a roofing material.

After Finland's independence, the country made self-suffi-

ciency in food production its primary goal. Although agriculture was the country's main industry, its production was soon not enough to feed the whole population – in the case of cereals, Finland was only 40% self-sufficient during 1911-1913. In order to achieve its goal, the country started to intensify and expand its production by creating more fields, by drying



In Finland, only one company utilised Common Reed industrially: Oy E. Sarlin Ab manufactured Berger reed panels in Porvoo in 1938-1944. Material for the reed panels comprised dried Common Reed, which was harvested from the frozen sea during winter. The stems were squeezed against each other and sewn together with wire to form thick panels. The reverse of the advertisement above states: "Berger panels are lightweight construction panels, which are manufactured from top-quality Finnish Common Reed. As the following description explains, its insulating properties are excellent, both with regard to heat and sound. Among the other specifications of the panels are: large size, which makes installation easier; does not shrink; is not flammable; withstands the effects of moisture (does not perish or go mouldy). Berger panels can be used in houses made of concrete, bricks or timber. It is also ideal for insulating storage tanks, boilers etc."



Making Berger plates in Saaremaa, Estonia, in 2006. Photo: Eija Hagelberg.

lakes to expand meadows, by improving the quality of cattle and other domestic animals through a programme of breeding, and by adopting more efficient machinery. There was an increase in scientific interest in both the qualitative and quantitative improvement in farm production. One of the interests was Common Reed, which was the subject of fodder and yield research in order to develop optimum collection methods and machinery. Among yeomen, the research and lectures about the excellence of reed were not met with enthusiasm; the collection of reed was perceived as hard and labourious, compared to the harvesting of hay. Instead, domestic advisory services aimed at women, which started in 1922, managed to raise interest in domestic gardening among the female population. This increased the use of reed mats for the protection of young plants.

During the war and rebuilding in the 1940s, Finland experienced severe shortages of raw materials and building supplies. Imports were restricted to the most essential items and it was not even possible to source those at all times. Attempts were made to ease the shortages by more extensive use of locally sourced materials and replacement materials. During the war years, there were shortages of down and other materials that had been adopted in the 1920s and 1930s, and the use of reed tufts was reintroduced as stuffing in mattresses and pillows. In these circumstances, Common Reed could be used in a variety of ways. For instance, in Hirvensalo, Turku, where it was used in one household to thatch domestic buildings, as fodder for the cattle, and in the market garden as reed mats to cover young plants.

In the 1950s the shortages decreased, as did the use of

Common Reed in domestic situations. In recent decades, individual farms have continued to use reed beds on the shore as grazing grounds for their cattle. Some others have protected plants with reed mats. A few enthusiasts have used reed as a building material in walls and roofs, and some replaced straw in decorative mobiles with reed. Now, in the 21st century, a new interest has surfaced in natural materials, among them Common Reed.

Collection of reed

Reed was mostly collected in summer and late summer, but some of it was also collected in winter from the top of the frozen sea or lake. Common Reed should be collected at different times of the year, according to its intended use: Reed that is intended for fodder contains the most nutrients around mid-summer. It should be collected at the latest when the flower tufts appear. Flower tufts that are intended for bed-linen had to be collected in September; this produced the softest stuffing. The reed intended for keeping cattle dry had to be collected before the first snows. The best reed for roofing was collected in winter, when the stems were hard. The moisture content of reed collected in winter or early spring was very low, and the flower tufts came off easily. In winter it was easy to collect reed on the frozen surface of the sea or lake.

The collection of Common Reed was started on a mutually agreed day, or some other suitable day. In 1445 in the village of Köyliö, there was a court order concerning a harvest of reed, to which the villagers in Pölsu had the right, and the court order stated that no-one must cut "the Common Reed before the day of Maria Magdalen" (on 22.7). The collection commenced on a different day in different areas, but as a rough guide it can be said that in the eastern part of the country, reed was collected from midsummer onwards, before haymaking, and in the western part of the country, it was collected after haymaking. The reason for this was that in the eastern part of the country, people only used reed as fodder for their cattle, whereas in the western part of the country, it was also used for other purposes. In the domestic arrangements of a house, it was important to ensure that the entire reed collection was carried out in one go.

Gösta Grotenfelt wrote at the beginning of the 20th century that one reason why reed intended for fodder was often collected too late was that people wanted to wait till the tufts were at their softest. According to him, the tufts were so much in demand in towns that it made up for the worse quality of

the part used for fodder. According to him, the other reason was that people were waiting for the optimum size of harvest, regardless of what it would do to the quality of the fodder. When the same reed bed produced winter fodder, roofing material and stuffing, people collected a triple-harvest in one go.

The reed collected in winter was used for fodder and litter in cowsheds; even in normal, non-famine years the farmers would find that by early spring, their fodder supplies had been depleted. In years when the harvest was poor, people resorted to using winter reed as a standby fodder for their cattle. Winter reed was also unsuitable for litter: "One year when there

were too few straws, we cut reeds for litter for the oxen, but it was not very good, it was too rough, and such rough reed doesn't absorb anything", remembers one farmer near the town of Hamina.

In summer and autumn reed was cut from the shoreline by scythe and sickel, with the cutter wading in water up to their waist in some cases. If cutting took place further from the shore, a small punt was used. The reed that was cut on the shore was called shore reed, and the reed that was cut from a punt was called boat reed. Cutters used special reed sickles or scythes, which were harder than normal tools. When cutting a reed, the cut had to be done below water level, in order to prevent water damaging the inside of the open pipes. Shore reed was removed from the water by a special carrying hook, by pulling it with rope, or in a hay cage pulled by a horse. On dry land, the reed was tied into bundles. The bundles were taken to a drying place.

When cutting reed in deeper water, the work was done from a punt. The punts were shallow and wide-bottomed boats that were easy to manoeuvre in the shallow muddy water. There were several people working at the same time in a dinghy, with the women cutting reed and assembling it into bundles. The men stood at either end of the punt to steady it whilst pushing it forward with some canes, which had a crossbar at the ends to stop the canes getting stuck in the mud. Sometimes two punts were tied together alongside each other with one being used for cutting the reed, and the other for storing it.

The reed bundles were allowed to dry in different ways outside in the sunshine, for instance on a fence, on the side of



Shore reed being cut with a scythe. Reed on the shoreline was cut on foot. The picture is from Mietoinen, Finland, at the beginning of the 1930s. Photo: Risto Raimoranta.



Cutting of boat reed from a punt in Mietoinen, Finland, at the beginning of the 1930s. Photo: Risto Raimoranta.

a barn, on a special drying stand, in the field stacked against each other or in a pit. After drying, the reed would be moved to a barn, or it was stored in a pit or a pile.

In winter, on the even surface of the ice, a scythe was used. When the reeds were cut with a scythe, they easily got tangled up and a sickle would also be used. On a frozen sea or lake, reed was sometimes also cut with a scythe blade attached to a kick sleigh or a plough-like construction. Reed cut like this remained in better shape and was easier to handle than reed cut in the ordinary way.

Prior to the division of land called the Big Division (which, in the case of forests, was not finalised until the end of the 19th century), reed beds were in communal ownership, as were fields, meadows and domestic forests. During the Big Division, they were transferred to private ownership, but water areas remained in communal ownership. The large and economically most significant reed bed areas were utilised by villages or specific households. Houses and villages were part-owners of an area of reed beds, each with an allocated section of the shoreline.

There were many ways of using the communal reed beds. Sometimes a communal reed bed was parcelled out and the allocation was done by drawing lots. Divisions between lots were defined yearly on a certain day, after which the reed was ready for collection in each lot. The other method was to organise a communal collection. Each house generally sent 3-4 people to do the work. The reed was tied before being divided into bundles. The bundles were divided into piles. As the piles were of different sizes depending on the size and quality of the reed, lots were drawn to allocate the piles to households. Sometimes the shares of cut reed were divided in proportion to the shareholders' tax liability or land ownership.

Even before the Big Division, there were private reed beds, such as in Ulvila where, in 1473, a court decided the following: According to the court's decision, each land owner could freely enjoy the "fishing grounds and reed beds within its own area". This decision referred to shore reed; boat reed was communally owned. In later times, farmers who owned reed beds could rent them out or sell the collection rights for a part-share of the harvest, or for money. The person renting the reed beds had to pay a share of the reed they collected to the land owner, and the share was sometimes substantial; for instance, in Mietoinen in the 1930s, it was half. In Säkijärvi in the 1920s, collection rights to the additional wetlands that were gradually created as a result of lake drainage were annually sold in small patches, "crumbs". The price of a "crumb" depended on its location and

dryness. The drier patches that were closer to the shore were more expensive. Reed was also sold and exchanged for other commodities. For instance, a farmer in Mietoinen exchanged his reed with a fisherman for some Baltic herring. According to a story, the fishermen preferred reed to money.

Common Reed as cattle fodder: quality and use

In 18th-century taxation, Common Reed was classified as a third-class grass, along with sedge and French sorrel. For taxation purposes, reed and grass were both counted as crown "parmas" (an old Finnish measure of volume) per acre. Although reed was taxed, it was not a suitable method of payment. After all, reed was tied into bundles, and the only things left for the cattle's winter fodder were the leafy tufts of the bundles. The rough rootstocks were wasted, because cows rejected the tough parts of the reed. This wastage was probably considered in taxation. The taxation value of Common Reed proves that it was an important commodity also for the state economy.

In his doctoral thesis, Michael Lunden describes the quality of Common Reed as fodder as follows: "For as long as Common Reed grows, and before its seeds start to ripen, the leaves and stems are soft, juicy and sufficiently sweet to make this plant one of the best for cattle fodder. We can also notice that cattle in the summer rush from the best meadows down to the shore whenever possible to the reed bed, where they eat reed until late at night. The increased milk production is definite proof of the excellent properties of the fodder."

The Little Giant of Agriculture in 1947 described reed as



fodder thus: “Common Reed is a good substitute fodder. Before flowering, reed contains more digestible protein than an ordinary mixture of clover and cat’s-tail. An average-sized cow can eat approximately 12 kilogrammes of this kind of reed and then earn its keep by producing 3 kilogrammes of milk. There is so much protein left over that if 1.2 units of fodder were replaced with some other easily digestible fodder, even one with less protein, the end result would be 6 kilogrammes of milk”. The Little Giant reminds us of the correct harvesting time of Common Reed thus: “It is particularly important that Common Reed is collected before it flowers, for even one week later the stems will be tough and difficult to digest. A cow can just about live on this kind of diet, but will not produce milk”.

These examples show that throughout the centuries, Common Reed was considered an excellent fodder when used green. The change in agriculture can be seen in the fact that in 1947, Common Reed was classified as subsidiary fodder.

Right up to the 1870s, the main use of cattle was to produce fertilisation for the fields. Besides this oxen were used to pull ploughs. For the production of manure man tried to keep so much cattle as possible, because the amount of manure

determined the quantity of the cereal harvest. Fodder for the long winter period was then collected from nature. In winter, animals were fed with grass, leaves, straw and water fodder, the most important of which was Common Reed. Cattle had little to eat in the winters and by springtime, were often weakened by the lack of food. A written memory from Uusimaa gives us a good description of the cattle’s feeding habits. According to the memory, the cattle of a certain manor house were in such poor shape by the spring that they could barely stand. The spring task of farmhands and hired workers was to help cattle out of the cowshed by carrying them, if necessary. What little fodder remained by the spring was of very poor quality, which weakened cattle further. Nutritionally poor reed was regularly cut for fodder in wintertime, not only during famine years. Common Reed was also fed to sheep, if there was enough of it. Reed cut in winter was later used as emergency fodder and litter. Common Reed was therefore an important fodder at that time. For some smallholders and landless people, Common Reed may have been such an important fodder that without it, they would not have been able to keep cows or sheep.

The significance of Common Reed as fodder decreased from



Reed being pulled ashore by horses. Mietoinen, Finland, in the 1930s. Photo: Risto Raimoranta.

the end of the 1870s due to the expansion of arable farming. Farming of hay soon made Common Reed obsolete as fodder. Hay was considered more valuable as fodder, and it was easier to grow. The collection of Common Reed was considered to be dirty and hard work, which is probably true considering that it involved wading up to your waist in muddy water on a hot summer's day whilst cutting reed with a sickle. Also, it was much easier to transport hay from the field to the barn than it was to transport reed from the reed beds or water. Among farm owners, reed continued to be used till the 1920s, and in some locations even later. For instance, among the reed-rich Southwestern municipalities, reed continued to be harvested in Askainen till 1930 and in Mietoinen until the end of the 1940s. Smallholders and the landless continued to feed their cattle with reed until the beginning of the 1950s, for instance in Hamina and surroundings.

Common Reed as thatching material

In Southern Finland, reed was sometimes used as thatching (roofing) material on its own, and sometimes mixed with straw. Reed roofs were seen particularly in coastal regions and the archipelago, where the availability of rye straw was limited. In Southwest Finland's archipelago reed was in plentiful supply and was used to cover shoreline barns and boat sheds. Reed was also used for thatching cowsheds and barns, and other smaller domestic buildings. Elsewhere in Southwest Finland, reed was predominantly layered close to the girders or used in eaves. This made the roof stronger and gave an otherwise straw-covered roof a sharper edge. A reed roof was considered stronger and much more durable: A well-made reed roof withstood wind better than a straw roof, and lasted up to 40 years, instead of 30 years for a reed-reinforced straw roof, and even less for a straw-only roof. The fact that more roofs were thatched with straw was due to the fact that it was more easily obtained than reed: straw was the by-product of harvesting and did not need to be collected separately.

In the late 19th century, shingle became more popular as a roofing material. This occurred after the invention of the shingle plane, which was referred to by an elderly farmer in Taivassalo: "In the olden days, they used to carve the shingles manually, which was such slow work that the shingles would have ended up as too expensive to be used on a barn". Reed was reintroduced as a roofing material in the 20th century because, since harvesting machines became more widely used, there is no rye straw left for roofing.

According to a roof maker from Rymättylä, the building of



*Restored reed roof of a barn. Rymättylä, Southwest Finland.
Photo: Markku Hyvönen.*

a traditional reed roof took place as follows: The roof must be built on a windless and sunny day, so that the wind would not disturb the straw and the bottom layer of the roof would be dry. The reed roof is built on top of the joists, which are spread 50 centimetres apart, or on top of the wooden roof. The roof is built from the eaves upwards towards the comb. Poles are placed on the ground against the eaves at the same angle as the flat part of the roof. Nails are sunk into the poles at the distance from the edge of the roof that is the desired width of the eaves. A plank of wood is placed on the nails to support the reeds. The reed bunches are placed on the outermost joist in such a way that one half of the bunch remains below the joist and one half above it. The stems of the reed bunches rest against the plank of wood with the flowerheads towards the comb. The remaining layers are placed in such a way that the later layers cover the tops of the previous layers. In this way, water runs down the roof without damaging it. First the entire length of the comb gets covered, then the whole layer is transferred into place in one go to ensure even coverage.

When the flats have been filled, small bunches are placed on top of the comb ensuring that the tops turn towards the two sides of the comb in turn. Knots are tied at the ends of the comb to stop the roof from falling down. Furthermore, added weight is put on the roof by placing spruces on it that have been trimmed on two sides. Their stems are fastened to the comb in a crosswise fashion using pegs. The spruces were put so close to each other than their branches were crosswise. The spruces that were nearest the edge were fixed to the joists. Pegs

were fixed to the spruces along the eaves to provide weight and, in the windiest places, stones may have been used. Planks of wood were placed on the roof from the eaves onwards. Finally, additional planks were removed and the edges of the eaves were made even.

The use of flowerheads as stuffing in mattresses and pillows

The flowerheads of Common Reed have been utilised as stuffing for mattresses and pillows. The flowerheads are at their best in September straight after flowering, after the reed has acquired its soft furry surface. The flowerheads would then be cut from the dried stems with wool shears or a special kind of knife. In some cases flowerheads were also collected in late winter, but the flowerheads then were naturally of a much worse quality. Poorer people collected the reed tufts in winter because they were then easily accessible by anyone.

Flowerhead-collecting was women's work which was carried out when the other outdoor jobs were finished, which meant that in many places, it had to wait till winter. In some locations it was customary for the women of the house to organise a bee for collecting the flowerheads. Children also helped. The best stuffing was obtained when the flowerheads were collected by hand, with a knife or scissors. This separated the tough stems, which would otherwise be felt through the mattress cover. The softer stuffing was used predominantly for pillows. The work was difficult and damaged the hands. The flowerheads were dried in a sauna or drying room until they were sufficiently fluffy. In some locations, the flowerheads were dried entirely naturally, by the sun. The smoke of the sauna destroyed small insects and the flowerheads acquired a faint smell of smoke that replaced the smell of mud. Flowerheads attracted insects easily, unless they were "smoked through". After extended use, flowerhead mattresses became grainy and lumpy, and the stuffing had to be replaced. In Bolax, Hiittinen, flowerheads were harvested each autumn from sun-dried Common Reed, and they were used to stuff the mattresses and pillows.

A well-made and smoked flowerhead mattress could last for 10-15 years – with restuffing, up to 25-30 years – which was considerably longer than a straw mattress lasted. A flowerhead mattress weighed 15-20 kilogrammes. A double mattress with flowerhead stuffing could weigh as much as 30 kilogrammes. It took about two kilogrammes of flowerheads to make one small pillow. It took two people a whole day to collect enough



The collection of flowerheads was women's work. Mietoinen, Finland, in the 1930s. Photo: Risto Raimoranta.

reed to stuff one mattress. Flowerhead mattresses were generally considered a lot more comfortable to sleep on than straw-filled mattresses. The stuffing of mattresses and pillows showed clear social differences, as was pointed out by one storyteller from Uusimaa: The rich in their mansion houses slept on down, the farmers had flowerhead mattresses and the landless used threshed or long straw.

The sale of reed flowerheads had economic significance. Reed flowerheads were a commodity until the 1930s and it was sold in markets and fairs. A further reason for reed flowerheads and down being commodities was the fact that in the countryside, mattresses and pillows were traditional items in wedding trousseaux. When a young girl came of age, she obtained "marriage flowerheads" for herself. If there were no flowerheads available, they had to be purchased. In shops the cost of flowerheads was calculated according to weight (a flowerhead pound á 8.6 kilogrammes). Reed flowerheads were normally sold as ordinary nail sacks, and a mattress took 2-3 sacks. On the other hand, reed flowerheads were a significant source of second income, particularly for poorer people and for people living in the archipelago.

In Turku, reed flowerheads were sold in the market square and directly from boats that anchored at the riverside. Even as late as the beginning of the 20th century, reed flowerheads were transported from Kustavi, Taivassalo and Rymättylä to the autumn market in Turku. A certain Rymättylä household sold annually 40-50 sackfuls of reed flowerheads, with each sack weighing 20-30 kilogrammes. The captains of galleasses and even bigger ships travelled around the archipelago and

bought reed flowerheads, which they went on to transport to the towns. During the farmers' sailing trips, reed flowerheads from Southwest Finland were taken even to Stockholm and Tallinn. In the olden days, trade with Tallinn involved reed flowerheads being transported alongside other products from places such as Taivassalo, and in smaller quantities to Sweden until the 1930s and 1940s.

Common Reed at rural festivals: mobile and Christmas decoration

The Christmas mobile is made of straw, reed or shingles, suspended from the ceiling, and is widely known in Europe. The mobile came to Finland from Sweden. The mobile was a rural Christmas decoration and did not feature in aristocratic families' Christmas celebrations. Mobiles have been used to secure a good harvest, and in farm houses one was sometimes left suspended from the ceiling until the following midsummer to ensure a good harvest. Mobiles were also used at weddings, suspended above tables. In the olden days, young women and

men used to be charged with making the Christmas mobiles. There were two ways of making one: either the parts were made separately and later joined by attaching the straws together, or they were made by weaving the straws together. The traditional Christmas mobile was gradually dropped from the Christmas celebrations from the end of the 19th century. It was replaced by the Christmas tree as the centre of the seasonal decorations.

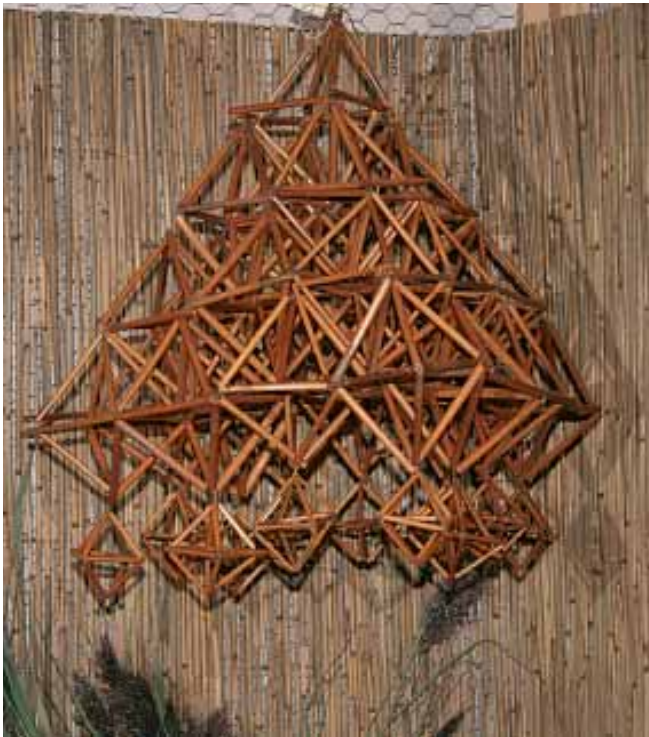
The very old-fashioned Christmas celebrations included covering the floor with Christmas straws. Instead of straw, reed was sometimes used. The use of straw and reed on floors was already a custom in pre-Christian times. These were originally a replacement for mats, and were a common floor covering in homes and palaces as well as churches. With the mats becoming more widely used, straw and reed disappeared off the floors. The arrival of straw or reeds on the farmhouse kitchen floor was a sign of the arrival of Christmas. The fortunes of the coming year were predicted by throwing the straws up in the air. The Christmas straws and reeds had to be treated with respect: they had to be kept separate from all types of work, and magical beliefs were attached even to their post-Christmas use.

Towards modern age

These days Common Reed has made Finland's waterways eutrophic on a worrying scale, which means that there is now plenty of raw material for using reed in various ways. These uses could be eco-building, energy use and different kinds of hobbies and handicrafts using natural materials. Reed beds could also be used increasingly as pastureland for cattle and sheep, and the rootstalks, as thick as root vegetables, could be used as concentrated feed.

The use of reed all but ceased in the 1950s mostly because its collection was so expensive and labour-intensive; there were no machines available in those days for this type of work. These days in Western Estonia, reed is collected from the frozen sea and lakes using cutting machinery. The reed that has been collected is cleaned of all leaves and flowerheads, and bundled in suitable lengths. The bundles are used as roof covering in several countries, for instance in Finland. The use of reed roofs has these days experienced a kind of a renaissance in Finland and the roofs are manufactured by enthusiasts and a few professional companies, albeit using Estonian methods and raw materials.

In construction, reed can be used for thatching, but also



A reed mobile purchased at Turku Puutori market square in 1925. Kuralan Kylämäki, Turku Provincial Museum. Photo: Eija Hagelberg.

in various types of reed panels and clay bricks. As well as the earlier-mentioned Berger panel, a German company has developed a clay-reed panel that is suitable for both outer and inner walls and floors. The clay-reed ingot also comes from Germany and is suitable for plastering walls. After finishing the brickwork, the outside of the ingots must be protected from wind, for instance by plastering it.

Common Reed is well-suited for providing energy. As a fuel, reed is similar to straw and, if collected in winter, it is somewhat better than straw. The moisture content will then be low and the effective heat value, therefore, relatively high. Reed can also be pressed into briquettes and pellets and, as with all vegetable-based substances, can be turned into biogas.

Common Reed would be a suitable natural material for hobbies and handicrafts in many different ways. Its stem is suitable for weaving and ornamental work ranging from traditional mobiles to garden fences and protective mats.

References

- Eloranta, M. 1978. Ruokokaton valmistus Rymättylässä. Interview research. Helsingin yliopisto.
- Grotenfelt, G. 1916. Vanhanaikainen suomalainen maatalous. Otava. Helsinki.
- Grotenfelt, G. 1918. Järvi- ja suokasvien korjuu karjanrehuksi ja kuivikkeiksi. Karjatuote. Helsinki.
- Huurre, M. 1998. Kivikauden Suomi. Otava. Keuruu.
- Iso Tietosanakirja, osat 10 ja 13. 1936. Otava. Helsinki.
- Isotalo, I., Kauppi, P., Ojanen, T., Puttonen, P. & Toivonen, H. 1981. Järviruoko energiakasvina. Tuotosarvio, tekniset mahdollisuudet ja ympäristönsuojelu. Vesihallitus, Tiedotus 210. Helsinki.
- Kimitobygdens historia. Del 11. 1982. Utgivare: Sagalunds hembygdsmuseum kommunalförbund. Ekenäs.
- Kuvaja, C. & Rantanen, A. 1994. Sibbo sockens historia. Fram till år 1868. Band 1. Jyväskylä.
- Maatalouden pikkujättiläinen 1947. WSOY. Porvoo.
- Mykkänen, M. 2003. Olki- ja ruokokatto Suomessa ja Virossa. Master's thesis. Helsingin yliopisto.
- Lundén, M. 1795. Om Wassen. Doctoral thesis. Åbo Akademi. Turku.
- Oksanen, E.-L. 1991. Vanha Pyhtää. Pyhtään ja Ruotsinpyhtään historia vuoteen 1743. Loviisa.
- Soininen, A. M. 1974. Vanha maataloutemme. Maatalous ja maatalousväestö Suomessa perinnäisen maatalouden loppukaudella 1720-luvulta 1870-luvulle. Historiallisia tutkimuksia 96. Helsinki.
- Storå, N. 1981. Rörvassen en gammal naturtillgång. In Skärgård 2/1981.
- Storå, N. 1981-82: Åländsk vasstäkt enligt lantmäteri- och byhandlingar. In Åländsk odling 42.
- Storå, N. 1993: Insamling av vass och dun i Finlands svensksbygder och på Åland. In Storå, N.: Resursser, strategier, miljöer, etnologiska uppsatser av Nils Storå. Åbo Akademi. Turku.
- Storå, N. 1995. Ihminen, järviruoko ja kulttuurimaisema. Projekt Muuttuva miljö – muuttuva yhteisö. Turun yliopisto, Åbo Akademi. Åbo Akademis Tryckeri. Turku.
- Suomen Maatalouden Historia 1. 2003. Perinteisen maatalouden aika. Esihistoriasta 1870-luvulle. In Rasila, V., Jutikkala, E. & Mäkelä-Alitalo, A. (ed.). Suomalaisen Kirjallisuuden seuran toimituksia 914:1. Jyväskylä.
- Suomen Maatalouden Historia 2. 2004. Kasvun ja kriisien aika. 1870-luvulta 1950-luvulle. In Peltonen, M. (ed.). Suomalaisen Kirjallisuuden seuran toimituksia 914:2. Jyväskylä.
- Talve, I. 1991. Suomen kansankulttuuri. SKS:n toimituksia 514. 3 p. Mänttä.
- Westermarck, M., Heuru, E.R. & Lundsten, B. 1998. Luonnonmukaiset rakennusaineet. Teknillinen korkeakoulu. Arkkitehtiosaston julkaisuja 1998/46. Rakennustieto. Helsinki.
- Wolff-Brandt, C. & Siekkeli, S. 2002. Juuret rantakalliossa. Naiskohtaloita Suomenlahdelta jäämerelle. Gummerus. Jyväskylä.
- Vuorela, T. 1998. Suomalainen kansankulttuuri. WSOY. Porvoo.

Interviews made for this article:

- Hakala Seija. Gardener (retired). 23. March 2006. Turku, Finland.
- Kaukiainen Olavi. Warehouse keeper. 16. February 2006. Hamina, Finland.
- Keskitalo Aimo. Farmer (retired). 23. March 2006. Taivassalo, Finland.
- Mukala Inga. Mistress of the house (retired). 15. February 2006. Vehkalahti, Finland.
- Mukala Tuure. Farmer (retired). 15. February 2006. Vehkalahti, Finland.
- Raimoranta Tero. Farmer (retired). 23. March 2006. Mietoinen, Finland.

Reed construction in the Baltic Sea region

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The natural construction materials market has been growing for several years, for instance in Germany (FNR [Agency of Renewable Resources] 2006, 57). Similar development is also expected in Finland, with the appreciation of eco-values growing and the knowledge of natural construction materials steadily increasing. New rules on reducing the amount of energy used to heat buildings have, in part, promoted a growth in the sale of insulating materials. Natural insulation materials, such as reed, will enjoy a corresponding growth in sales.

In Finland, reed was produced and used as building material before the Second World War, but the end of production, and of reed construction, means that we cannot really talk about Finnish traditions in reed construction. In several other Baltic states there are such traditions, however. Among these countries are Denmark, Germany, the Baltic States, Poland and, to a certain degree, also Sweden and Norway. When we extend the area to cover the neighbouring countries of these previously mentioned countries, we can also list countries with strong traditions in reed construction, such as Holland, Hungary and England. Reed has also been considered an excellent building material in Belgium, France, Austria, Switzerland, Turkey, Ireland and the Czech Republic. On other continents, reed is used at least in the following countries: the USA, Canada, Japan and Australia.

Of the countries of the Baltic region, Denmark matches Finland in population, but has 42,000 reed-roofed buildings (Jensen 2004, 14). If 100 Finnish houses were roofed with reed each year, which is an optimistic assumption, Finland would be 420 years behind Denmark in the use of reed! In the long term,



Reed markets of Europe.

these roofs would need to be repaired and replaced between 5 and 10 times, even though the lifespan of each roof can be as long as 40-70 years (Heuru, Lundsten & Westermarck 1998, 65).

Holland: forerunner of modern thatching

Holland does not lie on the Baltic Sea but, in the context of reed markets, it is included with the reed construction of the other Baltic Sea countries. Added to this, it is a good example of how to use reed imaginatively when the conditions are right.



Reed thatching is certainly one of the best-known Estonian traditions. A folk dancing show at Rocca al Mare, an open-air museum Tallinn, Estonia. August 2006. Photo: Eija Hagelberg.

Today, more than twice as many houses are thatched with reed in Holland than was the case five years ago. Holland also houses the world's largest single reed roof: the amusement park De Efterling, with more than 5,000 square metres of reed roof that, at its highest, rises to a height of 40 metres. The Dutch reed construction markets attract entrepreneurs from further afield. In 2004, an estimated 350 foreign roofing specialists were at work in Holland. Some of them were

authorised roofers from Belgium, Germany and Denmark, some were non-authorised entrepreneurs from Hungary, Poland and the Baltic States. (Jensen 2004, 105-108).

Reed construction markets are experiencing a boom in Holland. It has not always been like this, however. Measured in roof square metres, the number of reed roofs has varied significantly in Holland, as it has in England and Denmark. Statistics show that in 1981, there were more than two million square metres of reed roofs covering Denmark's industrial buildings. By 2003, i.e. in 22 years, the number of square metres had dropped to less than one million. Thanks to the country's policy makers, the overall figure is once more on the increase. (Jensen 2004, 92-93). In Denmark, a reed roof association was established in 1996 to promote the country's reed issues. Today the association has 1,200 members. (foreningen-straatag.dk)

In Estonia, 15,000-20,000 square metres of reed roofs are built each year. Reed is also exported to Denmark, Sweden, Germany, Holland and the USA (tansar.ee). The *Reed roof fire safety* instruction card was published in 2006 (Leis, Madalik & Rooda 2006).

The popularity and market share of reed construction can be seen in the volumes being cut. In Holland, 6-7 million bundles are collected annually for construction. In Denmark, the number has remained steady around the 2.5 million bundles



These buildings exemplify the modern style of reed construction. Reed can also be fitted to exterior walls, as in these examples from the Netherlands. Photo: The Dutch Federation of Thatchers.



Reed harvesting with an Estonian Seiga-harvester in March 2006 in Halikko, Finland. Photo: Eija Hagelberg.



Cleaning bundles of reed takes a lot of work by hand. Course participants in action in April 2006, Salo, Finland. Photo: Eija Hagelberg.

figure for several years now. In the case of Germany, the figure of 1 million bundles has been mentioned. (Sooster 2003, 8). In Sweden and Norway, the builders are mainly Danish roofing specialists. In Estonia, 0.8-1.5 million bundles are collected each year.

Reed construction is ideally suited for today's values, which encompass traditions, ecologically sound construction and lifespan considerations. Cutting and collecting reed reduces local eutrophication of waterways. People vacationing at their summer cabins experience the benefit of better visibility on their shores, and boaters have better access to waterways. When the cut reed is then used for construction, we can justifiably talk of a quadruple benefit from one cutting.

Whatever the intended end use, the cutting of reed beds must be planned carefully. It is recommended that a cutting and care plan is prepared for each reed bed, to ensure that the living conditions of the flora and fauna in the area remain as natural, rich and diverse as possible. Fish and birds must have sufficient shelter and nesting places even after the cut. (Denmark's Environment Ministry 2003, website). Each region's environment centre can give advice about issues to do with reed cutting.

In recent years, reed construction has started to expand northwards, with the Danish companies expanding their markets to South Sweden and Norway. In Finland, construc-



Reed is big business in Central Europe. This big store is located in the Netherlands. Photo: The Dutch Federation of Thatchers.

tion has taken place within the Reed Strategy project, which has made reed known as a construction material.

In Finland, the cost of a reed roof in small buildings such as summer houses is approximately 70 € per square metre (incl. VAT at 22%) and in larger buildings, such as huts, summer cottages and houses, approximately 80 € per square metre (incl. VAT at 22%). The price is dependent on the difficulty of construction: how many bays, skylight windows or other kinds of openings are needed, or whether the customer wants decorative waves or curves. The price per square metre includes the reed used and other costs. (ruokokatto.fi).

Reed entrepreneurship may expand in Finland once product marketing has managed to increase the demand, and the product and its specifications become better known. Completed projects are the best kind of advertising. It is hoped that once demand grows, the local authority planning officers can be encouraged to support the construction of reed roofs by allocating areas for such building projects. A growth in the demand for a new local building material would increase entrepreneurship and employment. On a larger scale, the supply chain would include machinery manufacturers, cutters, collectors, reed cleaners, bundlers, roofing specialists, suppliers of reed board and roof reed bundles, transport companies, retailers of fire-retardants and marketing specialists.

With such an expanse of coastal areas and shoreline, there is a lot of raw material in Finland. There are approximately 30,000 hectares of reed beds in South Finland alone (Pitkänen 2006, 14). It would be a useful local construction material. Reed could also be imported.

The supply of reed would, at least initially, satisfy domestic markets, provided that proper arrangements are made for cutting the reed. This means that there might be enough reed left over for exports. Finnish reed might do well because it is so clean: growing in the cold climate, our reed would probably contain fewer micro-organisms than reed grown further south. With winter lasting slightly longer than in the countries south of the Baltic Sea, the collection period for reed is also longer.

Reed that is used for construction is cut during winter, when the stalk is at its driest. Reed collected in winter also contains fewer micro-organisms. Before being installed in the roofing structure, the stalks are cleaned, sorted and arranged in bundles of a certain size. The circumference of a Euro bundle is approximately 60 centimetres.

Reed is mostly used in roofing, but also as insulation in walls and floor spaces, as well as a base material for plastering. As a

roofing material, reed is in a class of its own due to its uniqueness. A well-made reed roof has been known to last for 50-100 years (Sooster 2003, 6).

Roofing details have traditionally varied depending on country and area. These days, south of the Baltic Sea, reed is used for all types of construction and buildings. It is used for holiday homes, carports, detached houses, restaurants, blocks of flats, public buildings, residential houses and entire housing developments.

Unique installations can be created by varying the ridge types, tying methods and roof designs. Reed bends well and is, therefore, ideal for mitre boxes and curved designs. The roofing specialist needs to have a steady hand when finishing the roof and the expected age of the roof depends largely on his expertise. The product is, however, becoming so popular, for instance in Germany, Denmark and Holland, that hundreds of new roofs are built every year. Roofing associations drive research and development in the fields of fire testing and reed classification.

Thanks to its mechanical resistance, reed is an ideal roofing material. It withstands moisture, temperature changes, UV radiation, snow, ice and storms. This claim is backed by experience of reed as a durable roofing material. The roof must be maintained well and repaired from time to time. An annual inspection will show up any problems and will keep a reed roof in good condition.

Research activities and vision for the future

Of the recent research and development activities I could mention the RT-card (reed roof fire safety card), adopted in Estonia in 2006. It describes, with examples, the implementation of most popular reed structures. In Germany, at the Technical University of Lübeck, the use of massive timber sheets as a foundation structure for reed roofs is being researched, and 1:1 fire tests are being conducted on reed to try to obtain a fire classification in order to get reed approved as a safe building material. In Denmark, the Reed Roof Association is cooperating with the manufacturer of insulating materials, Rockwool, and the manufacturer of gypsum boards, Gyproc, to find a structure that would meet that country's fire prevention regulations. The insurance company Topdanmark is also taking part in this research.

In Finland, a lot of multidisciplinary data has been collected during the Reed Strategy project on the opportunities for using reed. The construction division of the project has



Aerial photo of a residential area in the Netherlands: almost every single house has a reed roof! Photo: The Dutch Federation of Thatchers.



*Beautiful detail on a mitre box.
Photo: The Dutch Federation of Thatchers.*

trained roofing specialists, gathered basic information on safe roofing solutions and undertaken real construction projects. Completed projects are the best kind of advertising for the product.

New EU-wide joint testing methods will promote the launch of new building materials. This is not yet the case with the testing of roofs: the member states can choose which of the three test methods to adopt. For instance, in Germany a different testing method is in use than is the case in Finland. A product that has already passed the appropriate tests in Germany also has to pass the Finnish safety tests, before it can be classified as being safe for use in Finland. Reed and reed-based construction sheets have not been officially tested in Finland and, therefore, they are unclassified materials. This does not prevent their use. Based on long experience, reed can be considered as a good building material for insulation, as a background material for plastering, and as a roofing material. This has been the case in Germany, Sweden, Denmark and Estonia. Why not also in Finland?



*Reed expert Siim Sooster from Hiiumaa, Estonia (below left) teaching Finnish course participants in Salo, Finland, in August 2006.
Photo: Martti Nakari.*



The first Finnish modern house with a reed roof is located in Pihtipudas, Central Finland. Photo: Juha Kääriä.



*Obviously the world's largest single reed roof is located in the De Eferling amusement park. This roof measures over 5,000 square meters.
Photo: The Dutch Federation of Thatchers.*

Refereces

- Al-Khazarji, K. 2004. Järviruo'on hyödyntäminen rakennusmateriaalina. Thesis work. Tampere Technical University. Construction Technology Department.
- C2 Finnish construction regulations, moisture content, regulations, instructions. Ministry of the Environment. 1998.
- C3 Finnish construction regulations, insulation of buildings, regulations. 2003.
- C4 Finnish construction regulations, insulation of buildings, statute. 2003.
- CMA Deutschland, Dämmstoffe aus der heimischen Natur. Bonn. 2nd edition 2002.
- E1 Finnish construction regulations, fire safety of buildings, regulations, instructions. Ministry of the Environment. 2002.
- E3 Finnish construction regulations, structure and fire safety of small chimneys, regulations, instructions. Ministry of the Environment. Statement of 16th June 2006.
- Ekholm, S.1995. Saksan rakennussuunnittelun käsikirja. Rakennustieto Oy. Tammer-Paino Oy. Tampere.
- FNR, Fachagentur Nachwachsende Rohstoffe e.V., Dämmstoffe aus nachwachsenden Rohstoffen. Berlin. 2006.
- Heuru, E-R., Lundsten, B. & Westermarck, M. 1998. Luonnonmukaiset rakennusaineet. Helsinki Technical University.
- Jantunen, J. 2007. Chief Engineer, Ministry of the Environment. E-mail interview 2nd April 2007.
- Jantunen, J. 2007. Chief Engineer, Ministry of the Environment. Telephone interview on 10th April 2007.
- Jensen, J.K. 2004. Det levende tag, Historien om stråtage og taekemaend. Narayana Press.
- Karila, K. 2007. CEO, Tyco fire & integrated solutions, Helsinki. Telephone interview 10th April 2007.
- Leis, M., Madalik, A. & Rooda, G. 2006. Roogkatuste tuleohutus, Eesti ehitustea, ET-2 0506-0676.
- Liikanen, E. 2001. European Union Official Magazine. European Commission.
- Madalik, A. 2007. Work Supervisor, NCC Building Oy, Tallinn. Telephone interview 3rd March 2007.
- Müller, R. 2005. Regeln für Dachdeckungen, Deutsches Dachdeckerhandwerk. 5th edition.
- Pitkänen, T. 2006. Missä ruokoa kasvaa? Järviruokoalueiden satelliittikartoitus Eteä-Suomen ja Viron Väinämeren rannikoilla. Turku University of Applied Sciences publications, Puheenvuoroja vol. 29. Also available in internet www.ruoko.fi/julkaisut.
- Reissen, R. 2000. Untersuchungen zu Blitzschutzmassnahmen an modernen Reetdächern. Thesis work. Fachhochschule Aachen.
- Reuter, H. 2007. Architect, Jyväskylä, Finland. Telephone interview 2007.
- Construction foundation RTS, RT-cards, history-CD. Rakennustieto Oy. RT-cards 1943-1960 Helsinki 2002.

- RT 852.1, Kate, korsi-, The Finnish Association of Architects. Helsinki. 1943.
- Schrader, M. 1998. Reet und Stroh als historisches Baumaterial. Ein Materialleitfaden und Ratgeben.
- Slama, S. 2007. MSc, Lübeck University of Applied Sciences, R&D Department. E-mail interview 22nd March 2007.
- Sooster, S. 2003. Ruoko- ja olkikattojen valmistusopas, Oy Rooekspert.

Electronic sources:

- Brandstriket stråtag, Denmark. www.brandmaerkning.dk. [ref. 23.2.2007.]
- Foreningen Straatags, Denmark. www.foreningen-straatag.dk. [ref. 23.2.2007.]
- Villa Steamcastle, Finland. www.steamcastle.com. [ref. 3.4.2007.]
- Knauf Danogips A/S, Denmark. www.knaufdanogips.dk. [ref. 4.4.2007.]
- Regionalhaus Lübecker Bucht, Germany. <http://www.regionalhaus-luebeckerbucht.de/index1.html>[ref. 28.3.2007]
- Reed strategy in Finland and Estonia – Interreg IIIA. www.ruoko.fi. [ref. 30.3.2007.]
- Kelopukki Oy, Finland. www.ruokokatto.fi. [ref. 27.3.2007.]
- Rupako Detection Systems, Netherlands. www.rupako.nl. [ref. 29.3.2007.]
- Sarlin, E. 1942. 10 years of industrial and social service. Advertising brochure. Suomen kirjallisuusseuran kirjapaino Oy. Helsinki. [http://www.digi.lib.helsinki.fi/pienpainate/secure/main.html/julkaisijaselailu/ E.Sarlin](http://www.digi.lib.helsinki.fi/pienpainate/secure/main.html/julkaisijaselailu/E.Sarlin). [ref. 13.4.2007.]
- Sepatec - Fire protection system for thatched roofs, Denmark. www.sepatec.dk [ref. 28.3.2007.]
- Taekkevejlægning, Taekkevejlægningen. Dansk Taekkevejlægning. 2006. www.taekkelægning.dk/vejledning/taekkevejlægning.pdf. [ref. 23.2.2007.]
- AS Tansar EF, Estonia. www.tansar.ee [ref. 22.3.2007.]
- www.wikipedia.org. Search under: Thatch. [ref. 3.4.2007.]

The fire safety of reed in construction

Andres Madalik, Construction Director in Koger & Partners AS.

The first mention of reed roofs originates from ancient Rome, where Pliny the Elder in 66 AD noted that northern peoples used reed roofs that were very durable.

Reed is a naturally renewable roofing material. Nowadays, when less cattle are kept on coastal meadows, reed has claimed more space and started to cause all kinds of problems. For instance, the habitats of birds in coastal meadows has diminished, and wild animals have easier access to birds' nests etc. The benefit of a reed roof, compared to other roofing materials, is its excellent sound and heat insulation properties (U ca $0.25 \text{ W/m}^2\text{K}$).

A reed roof is very light; including battens, it only weighs 40 kg/m^2 , which makes its load-bearing structure relatively

cheap and easy to build. The foundation structure of the roof does not have to be absolutely straight. Builders have recently learned to make more complicated roofs with additional structures and skylight windows, which make the buildings extremely beautiful and unique.

With the growing popularity of reed roofs, fire safety has become an issue. During dry periods, reed roofs are relatively inflammable and their combustion temperature is very high, which makes it difficult to construct a reed roof in a built-up area. Fire can spread very quickly in a reed roof in certain circumstances, and it may be difficult to put out a fire, because sparks from the fire can be carried some distance away from the fire.

It is important that chimneys and fireplaces that let smoke through the roof are properly constructed. The wall of a brick-built chimney must be at least the thickness of one brick. If the wall is the thickness of half a brick, the air conduit of the chimney must be encased in a protective pipe. At the point where the chimney passes through the roof, and for about 50 centimetres down from the entry point, the chimney should be plastered to a thickness of 3 centimetres or insulated with thermal insulation material.

A lightweight metal chimney must not pierce a reed roof. A separate spark catcher must be installed at the end of the chimney. Reed roofs are not as inflammable as is generally assumed. Reed has been used as a roofing material for more than 1,000 years and roofs have lasted without any special measures for 60-80 years



A burning test with a small reed-roof model. Photo: Carlo F. Christensen.



*While burning, the reed roof is covered in thick smoke. In this 1:1 burning test, a fireproof fabric has been used on the roof.
Photo: Carlo F. Christensen.*

and, if the ridge and critical points of the roof are reinforced, for even longer. You can see reed-roofed houses in the small towns of Holland, Germany and Denmark alongside other types of houses. Due to the special characteristics of reed roofs, there is often a certain amount of moisture inside the roof that finally dries during an extensive dry spell. The underside of the roof is extremely inflammable, however. The reed tufts on the underside are dry and if the ventilation is good, the roof will burn particularly fast and with great intensity.

Different kinds of fire prevention methods have been adopted of late. The easiest method is to allow the completed roof to absorb a special liquid that makes the roof less likely to catch fire. The absorption liquid is sprayed into the roof with a high-pressure pump in the direction of the reed stems in order to ensure the deepest possible absorption into the roof. These absorption liquids are manufactured in Holland

in the main; they are safe for health and the environment, and they do not change the colour of the roof. Among products with the appropriate certification are Pyrobreak by K.Vaartes, Pyronova by Qchem and Magma Firestop SG-2H by Magma. The problem with this method is the relatively high cost of the absorption process, and the need to re-treat the roof every 3-5 years because the protection gets worn away by climatic conditions. The effects of absorption liquids on the lifespan of the roof are not known either. The method is common in Holland, Germany and England. Another method involves restricting the flammability and the air supply to the roof from below. This method means building the roof in such a way that if it should catch fire, the rest of the building would not get damaged as the supply of oxygen underneath the roof is minimised. Studies have shown that the intensity of the burning is then much less, the temperatures are lower, and you can stand within a few metres of a burning roof, which would not be possible if the roof is unprotected and open on the underside.

In Denmark, reed roofs have for a long time been protected from the underside with solutions developed by Rockwool and Danogips, which involve the use of a separate layer of rockwool and fireproof plaster. The problem with this method is that there is no ventilation to the roof from below, which shortens the lifespan of a reed roof because the reed will dry more slowly and retain moisture for longer in the roofing layer.

This method has been used the most in Denmark, and it enables the attic to be used as living space. Of late, tra-



*A fireproof fabric is laid out above the timber and below the reed.
Photo: Carlo F. Christensen.*

ditional wooden ribbing has widely been replaced by OSB sheets (similar to plywood), to which the reed is attached with special OSB screws that have wires for tying the reed. Tests have shown that this produces almost the same effect as the previous method in the event of a fire. The negative side of this method is the fact that the reed cannot be tied in the traditional way, and this method is therefore unsuitable for projects in which the traditional look of a building needs to be maintained (museums, restoration projects etc). Furthermore, as with the previous method, it makes it more difficult for the reed to dry, which in turn shortens the lifespan of the roof.

The so-called Sepatec method was introduced in Denmark recently. In this method, the ribbing is covered with a separate cloth that allows air through to the roof but, in the event of a fire, blocks the passage of air from below. It should, therefore, not shorten the lifespan of the roof. Rockwool is used for additional insulation at critical points (chimneys, skylight windows, eaves). If using this method, reed is not tied in the traditional way by tying wire underneath the ribbing. Instead, only screws are used.

Particular care must be taken to ensure that the cloth is not damaged during installation. If damage does occur, however, the damaged section must be repaired with a patch made from the same material. Tests undertaken by Denmark's fire service and the Fire Technical Institute have shown that should a fire occur whilst this method is being used, the firemen could stand within a couple of metres of the roof to put the fire out. When a fire that lasted for 30 minutes was put out, the firemen saw that the ribbing had not caught fire. Because the cloth is not very expensive and does not need to be replaced, this method is inexpensive compared to the absorption method or the use of fireproof plaster.

Special signs have been introduced in Denmark to notify the fire authorities of any additional fire prevention methods used in reed roofs. These signs are displayed in visible places on buildings. The emergency services will then know how to handle a fire.

Reed can also be used to make mats and plastering sheets for houses. A single-layer reed mat is mostly used in plastering, but sometimes also for decorative purposes. If a reed mat is used inside the house, it is particularly inflammable, and in densely populated areas it should be treated with a fire preventative substance intended for reed roofs. If a reed mat is used underneath plastering, it does not need special treatment.

Reed sheet is usually made in a 3-5-centimetre thickness, and it has excellent heat and sound insulation properties, as does reed roof. Measurements made by Tallinn Technical University as part of their research project gave reed sheet a thermal resistance reading (Lambda value) of 0.0555 W/mK – 0.065 W/mK , which is weaker than that of light wool or polystyrene.

The advantage of a reed sheet is that it can be plastered straight away, without the need for a separate plastering net; the sheet itself is fairly stiff. The reed stems are pressed tightly together and, therefore, a reed sheet burns slowly and is not highly inflammable. As reed does not retain water, this material is not as sensitive to temporarily raised moisture levels as different types of wool are and, with the right kind of wall structure, there is guaranteed movement of moisture - i.e. drying.

The durability of reed as a material manifests itself when old houses are dismantled: workmen sometimes find 60-year-old reed mats still in perfect condition.



A plaster-finished reed wall. Photo: Hartwig Reuter.

Reed and reed residues can also be used to make pressed reed balls, which can be used to fill gaps in timber; they can later be plastered on either side. Plastering also reduces the danger of these houses catching fire, but one should still be extra careful with boilers and heaters in a building like this. This is one way of erecting warm lightweight buildings effortlessly and cost-effectively. A similar building method (albeit using straw) has been popular, among other places, in Canada.



*Hartwig Reuter is “trying” to burn part of a Berger plate, which is an insulation plate made of reed. This thick plate is not easy to burn.
Photo: Iiro Ikonen.*

More detailed information in
Estonian Standard ET-2 0506-0676

Flexible reed

- The use of reed in handicrafts, art objects and fine art

Outi Tuomela, M.A., Turku University of Applied Sciences

During the past two years I have met different kinds of reed masters and experts. Many of them took part in 2006 Kurala Kylämäki Reed and Other Pipes -exhibition in Turku and the Green Art event in the vicinity of Halikonlahtibay in Salo region.

Common Reed is a versatile material in any season, but working with it is particularly inspiring during summer. In winter, reed is woody and more difficult to cut without splitting it.

Green Art is an art form that focuses on environmental protection, in which an ecological way of thinking goes hand in hand with aesthetics, ethical issues and creative energy.

Reed experts who utilise Common Reed in their handicrafts and art want to promote the use of reed by their own example, and thus prevent the spread of reed-grass in waterways. I posed the same questions to all reed experts interviewed. In this article they discuss their own relationship with nature and natural materials. I asked each interviewee what they find inspiring about reeds, when and how they use them, and where it is possible or advantageous to collect them.

Reijo Lillukkamäki: Reed mobiles and plant stands

"I have made decorative mobiles since I was a boy. More than forty years ago I started by repairing old straw mobiles and by building new ones. I switched from straw to Common Reed in the 1990s because fertilised straw was no longer of sufficient quality. The best time of the year for reed collection is October and I find suitable reed of even thickness by the fieldsides. After collecting the reed, I let it dry indoors for three days. The stems are not of even quality; the surface is softer under the leaves. I cut the reeds to the desired length with a narrow-bladed jigsaw on a stand that I made specially for this purpose. The mobile is made up of reed cubes that are of the same size to the nearest millimetre. This is also how I build the plant stands, the corners of which are reinforced with wood glue."

Lillukkamäki makes large handicraft installations for public spaces. The mobiles are huge, sometimes up to 3 metres tall, and they have been on show in several exhibitions and churches, with the latest installation displayed in the lobby of Salo health centre. The plant stands are approximately one metre in height and decorate several offices and hallways.



Reijo Lillukkamäki's hands-on work. Photo: Outi Tuomela.

Cornelius Colliander: Mats, lampshades and wall dividers

"I got my idea for reed mats a few years ago at Turku Horticultural Show. Aura Trädgårdsvänner (Aura Friends of Gardening) exhibited reed mats, which in olden times were used to protect plantations from frost. The simplicity of the weaving technique (a few stretched strings, upon which the reeds are tied with separate reels of cotton) gave me the idea of developing a system that could be used as occupational therapy for the severely handicapped.

I prepared the weaving frames, which were used to make wallhangings of approximately 60 x 60 centimetres in size. Once framed, these wallhangings looked very handsome. I also developed a simple tabletop loom, which enabled the weaver to work at a table, with the finished mat forming a roll under the table. The warps (x 5) were fed from a roll fixed to the table-edge closest to the wall. The mat had tongues on either side of the mat.

I have been harvesting Common Reed from a boat in the autumn by driving the boat into a reed bed in a place where the reeds grow tall. I then cut a handful of reed stems in one go using a sickle. I lay the stems across the sides of the boat and cut their tops after I have bundled them together. I then spread the reeds on a tin roof to dry, after which they are once again bundled for storage. If I have time to peel off the skin after harvesting, there is no danger of the reeds going mouldy. A useful width for a reed mat is 120cm at the most. After weaving the mats, their edges are straightened with scissors.

I have used reed mats as wall decorations, tabletop coverings for market stalls, as curtains, room dividers, acoustic sheets and ceiling coatings. The material is beautiful and the knots make for an exciting rhythmical surface. When stretched in a frame, a mat will stay straight and the edges will remain covered under the frame, or inside it if a U-frame is used. I have also covered lampshades with Common Reed. The conical shape of the reeds complements beautifully the shape of the lampshade (provided it is not too abrupt) and the lamp gives out beautiful light. I have glued rice paper inside the lampshade.

I am particularly interested in the beauty of natural materials and in their significance to man's development. In my opinion, the material must not be treated roughly. Instead, an artisan must learn to listen to it and respond accordingly. A good piece of handicraft must be two things simultaneously: made by man and produced by nature."



Cornelius Colliander's lamp. Photo: Eija Hagelberg.

Terhi Huuskonen: Reed cloths, net curtains and reed laces

"I have woven reed cloth on a loom using different kinds of bindings and materials such as paper string, poppana and rags, as space fillers, and woven reed art textiles on a loom and reed board.

In my spare time, I have built a primitive loom with my friends on the banks of Särkilahti bay. Because the home-made loom was so wide, it took four people to weave on it: two people to weave reed bundles between the strings and, in order to create a space, two people to lift the cane to which those strings are tied. Weaving a reed mat promotes team spirit, just like certain team sports do. The completed mat was handsome and fragrant, and it was lovely for us to throw ourselves on it.

I prefer the summer reeds collected in August. Reed contains a unique world of colours, which is understated and earthy."

Erika Holmbom: Café curtains, lampshades and experimentation diary

"I start collecting reed at the beginning of June, after Midsummer, and go on to collect a lot particularly in July when the largest and most uniform reeds can be found. Narrower reed is suitable for café curtains, the thicker reed for wall mats. Reed varies in quality and colour depending on what time of the year it is collected, and even depending on the year that the collection took place. Sometimes our seashore at Houtskari contains lots of reed, sometimes high tide takes it all away.

I cut the reed on site with a pair of Fiskars scissors; the night dew keeps the reed fresh for longer. If the reed is bone dry, it will crack. My style involves doing things as primitively as possible; simplicity is attractive. The warm colour and traditions of reed inspire me. I use the same weaving method that gardeners have used throughout the centuries when weaving their gardening mats to protect against night frost. The strings I use are hemp, linen and paper.

It is challenging when something of merit is created from something of no value. Let's give the hated reed the respect it deserves! This constantly changing plant radiates beauty."



Making a gardening mat in traditional style. Photo: Outi Tuomela.



Terhi Huuskonen with reed curtains. Photo: Outi Tuomela.



Examples of handicrafts by Erika Holmbom. Photo: Outi Tuomela.

Anna-Lea Kopperi:
Ruoko (Reed) - environmental installation

"My environmental installation was intended to look at Common Reed in a cultural landscape in an ecologically sound way, and to make a minimalistic gesture that represents man's chances of influencing the ecosystem of the Baltic Sea. During Halikonlahti Green Art exhibition, I created an installation of reed cuttings at Tammerpää shore that were clearly visible to passengers on a connecting ferry. This was intended to remind people of ways to prevent eutrophication.

It can be good to cut Common Reed sufficiently often to maintain the polymorphism of nature. In order to control the occurrence of Common Reed, it is sensible to cut it twice a year, in winter and summer: the winter cutting will increase the reed's value as fodder for animals in the summer.

The work included winter and summer cutting and provided a localised environmental installation. The cutting areas comprised surprising viewpoints that stood out in the shore landscape. Their aesthetic value made the prevention of eutrophication more visible."

(Photo of Anna-Lea Kopperi's Reed installation on the back cover. Photo: Jarmo Markkanen.)



Cutting reed for art installation. Photo: Jarmo Markkanen.

Kimmo Kuusinen: Reed paper sheets and envelopes

"I have used Common Reed on a small scale to make letter paper and envelopes, and other types of paper and boxes. But these days I have increasingly invested my time and money in my environmental laboratory.

Common Reed is the best material and the final result looks interesting. Reed is labouriously cut with scissors here on the banks of the Fiskars factories in early spring, and afterwards it is cut with scissors into 1-2-centimetre pieces to be used in paper-making."

Sirpa Arponen: Reed cloths and pictures

"There is a lot of reed growing on my own seashore in Askainen bay. This gave me inspiration for all types of reed objects. I wanted to make the most of reed. I have tried all types, but the plant is very hard and stiff to work with. Along with straw, I use reed in woven Christmas tablecloths and make pictures by gluing short pieces of reed upright."

Anni Rapinoja: Reed coat and other kinds of art

"I have made objects of art from reed for almost 10 years now. In 2003 there was an exhibition entitled Phragmites australis - Common Reed in Helsinki at Galleria Valöör. All the objects at the exhibition were made of Common Reed.

All my work these days is based on nature, which acts as my partner in art. I avoided Common Red for a long time. I imagined it to be a difficult working partner. But it would not leave me in peace. It "demanded" to be allowed into my studio in all four seasons, in various shapes and colours. It is one of our most typical and problematic plants and we ourselves are to blame: the eutrophication of waterways is our doing. The idea is to display the relationship between man and nature - after all, man is a part of nature. We are naked without nature, although we may not always appreciate this because everything can be bought in shops and we don't necessarily consider what is at the end of the trail - i.e. nature.

I often have to build some kind of an inner structure to support my art objects. Some inner structures are made of hardened silk paper and rye porridge. Sometimes I find something suitable in materials, such as old coats, which are to be recycled. Sometimes I find a suitable pattern, which I will use to cut and saw the new shape. In large works, the stem can be thick card reinforced by a wooden structure. I use different kinds of wood glue for fixing Common Reed.

The world of Common Reed is also interesting when videoed in different kinds of light; last summer I displayed a video as part of my Suhteita (Relationships) installation at Salo Art Museum in Halikonlahti Green Art Exhibition.

I collect reed in Hailuoto, where I live. Seasons feature prominently in my works. For instance, my installation called Big Bang comprises "tufts" of different colours, collected at different times of the year. Many other works are also dependent on seasons. It is interesting to be dependent on seasons in one's work. I naturally have to collect reed of a certain colour in a particular season. You cannot say I have no time right now, let's wait a while. Nature will not wait and you learn to prioritise. If you miss your chance, you will have to wait another year before the next one comes along."



Reed coat. Photo: Anni Rapinoja.



Making reed paper. Photo: Outi Tuomela.

Paolo Battilana: Aquarelles on reed paper

"Being an artist, I have always been interested in different kinds of materials when making a picture. It gives us an opportunity to realise our artistic flair and create an atmosphere in a whole new way. Reed paper inspired me instantly, and also from the ecological point of view. In my watercolour paintings, reed paper shines through the colours."

Tea Lanh: Photo prints on hand-made reed paper

"I collect the reed needed for paper-making during summer months on the banks of Lake Littoinen, or from nearby fieldside ditches. I then cut the reed to 10-centimetre lengths. In the summer, the reeds are soft and delicately coloured. In hand-made paper I am particularly interested in the merging of old handicrafts and new technologies; how the old methods are used alongside the new ones to create today's trends. I have printed my own art photographs onto hand-made sheets of reed paper."

Saima Huuskonen: Oasis and flower arranging

"My diploma work at Southwest Finland Agricultural College dealt with the preparation of vegetable fibre paper at a florist's shop, in other words creating a product that can be used by florists. When deciding the theme for my diploma work, my clear objective was to promote nature and the use of natural materials. I tested vegetable fibre paper in the preparation of an oasis (a small base used in flower arranging), and also tried printing a lace motif on the paper. Using vegetable fibre paper as an oasis gives florists more ways of creating personalised bouquets. Thanks to the oasis, the florists can create personalised bouquets quickly and effortlessly. Even modest stock items can be made to look expensive by wrapping it in a sheet of lacy vegetable fibre paper. My test plants were Cat's-tail, Stinging Nettle and Common Reed. Common Reed produced solid sheets, which were suitable for lace printing. The lacy effect was created by pressing a piece of lace against the wet paper mass during pressing. It is easy for florists to utilise reed lace paper by wrapping it around rose or tulip bouquets when selling these to the customer. Lace paper is also ideal for making different types of cards."



Photo print by Tea Lanh on handmade reed paper. Photo: Tea Lanh.

Tiia Tilus: Designing space

"I have contemplated the superb adaptability and adjustability in space of Common Reed and the possibilities of using reed in spatial architecture.

You can sense it, smell it, feel it, and amend it in countless different ways. I have bundled and collected and piled and bound reed in various different ways. The subjects of an interior design student are small prototypes on her desk. The walls/dividers of pictures have been shaped and plastered with lime plaster."

Turkka Aaltonen: Survival literature

Survival trainer Turkka Aaltonen has written many books that contain information on the use of Common Reed. Among other things, Aaltonen teaches survival techniques out in the open to wilderness and nature students. The rootstalks of Common Reed are edible in spring and the summer leaves can be used to make strong string and rope. In winter, the stems can be used for carving excellent reed pens to be used for calligraphy.

Jarkko Aallonloiske: Reed pipes

"I usually make a reed pipe out of Common Reed that has wintered and the stem is, therefore, sufficiently woody. I remove the felt-like layer on the inside of the reed by scratching it with a thinner straw and close the knot at the end that will be used for blowing. I was taught to build instruments by the Ingrian shepherd and musician Teppo Repo (1886-1962). Shepherd music was used to attract each other's attention and to communicate, to frighten wild animals and evil spirits, and even to drive away loneliness."

Yrjänä Ermala: Reed and bagpipes

"Bagpipes have been played in Finland and elsewhere in the Baltic region since the Middle Ages. The reed used for bagpipes is collected in the winter from underneath the sheets of ice, when the stems are waxy. The reed that grows below water level is naturally tougher and has thicker stems than reed growing above water level. The space between knots is shorter and one plant will produce 2-3 useful lengths for bagpipes. If the reed is collected too late in the spring, it is wrinkly after drying. Reed that has grown above water level cannot withstand the changes in moisture that take place inside the bagpipes when they are being played."



Jarkko Aallonloiske playing the reed pipe in Kurala village museum, Turku, in June 2006.
Photo: Eija Hagelberg.

Estonian plant art and living reed history

Aino Pajupuu (1931-2006) in Memoriam

The talented plant artist, teacher and agrologist Aino Pajupuu is alive in our memories.

Aino's large (up to 3 metres in height) plant gobelins, plant mats and different kinds of flower arranging and sawing installations were unforgettable works of art in several exhibitions in the 1990s, for instance in Helsinki and New York. Many Estonians are familiar with Aino's works from the interior design of restaurants and the staging of several TV programmes over a ten-year period, including some by the country's most famous singers.



Aino Pajupuu (1931-2006) in Memoriam.
Photo: Anne Erlach.

Her plant art was based on artistic non-symmetrical designs and wild creativity.

Aino's favourite plants were the sedge family and bulrushes, and she was particularly inspired by the annual summer reed festival in Mahu, Estonia, which goes by the name "Pilliroofestival Mahu rannas". Aino had a number of students, towards the end of her life particularly children. The effects of Aino Pajupuu's plant arrangement and creativity live on in her students, many of whom are now teachers themselves.

Niina Freiberg: Plant art teaching in Tartu and Mäntsälä

A student of Aino Pajupuu and the teacher of Tartu's Art 6th Form College, Niina Freiberg, also taught plant art to Finnish plant enthusiasts at Mäntsälä Technical College in 1993-2003. She collects her materials throughout the year. Niina considers reed a difficult material when working with children, because it tends to hurt their hands. With her older students, Freiberg has created gobelins, mats, dishes and wall dividers by combining reed with other materials.

Marike Laht: Decoration at Rocca al Mare

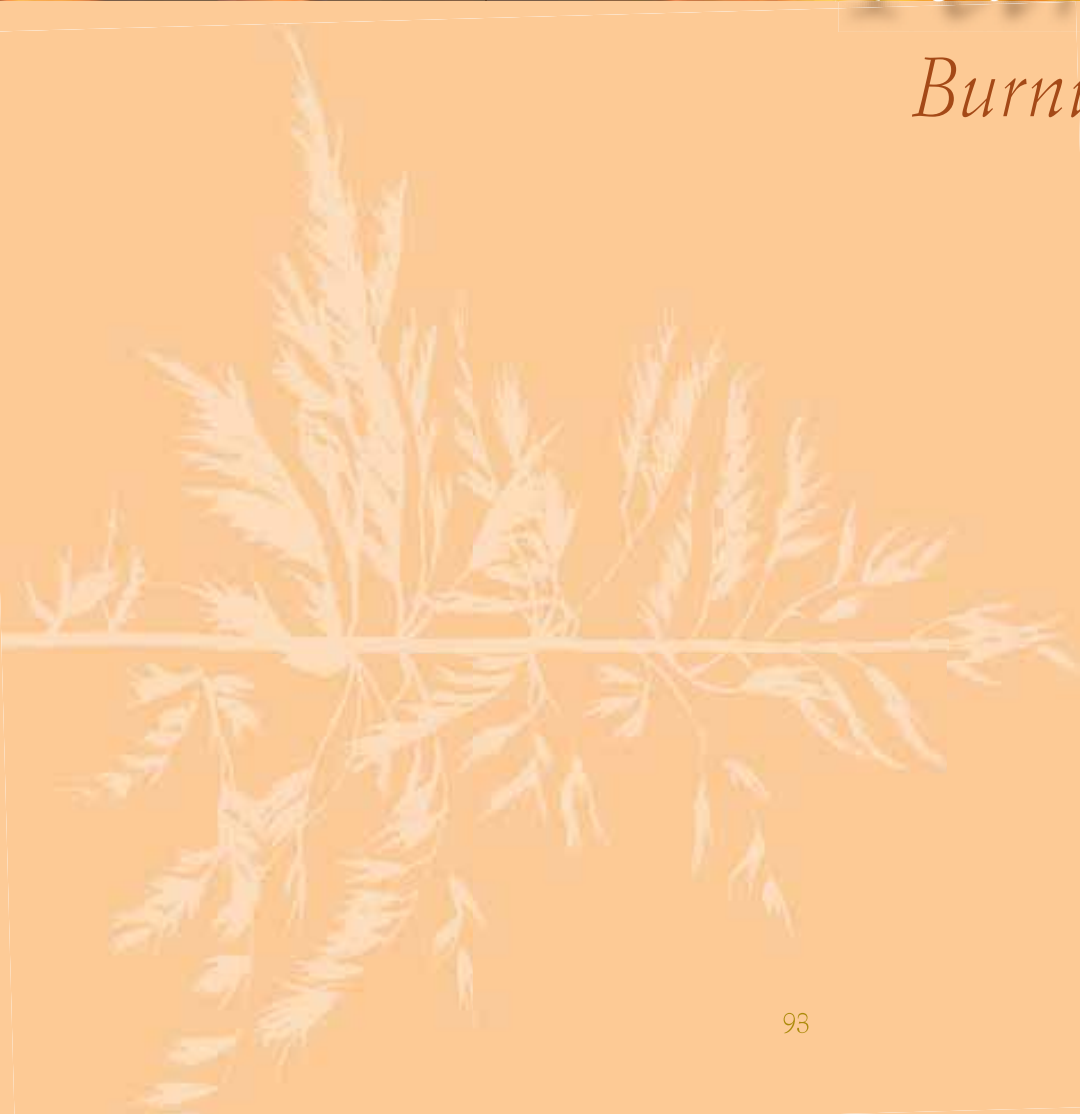
The art conservator of Rocca al Mare, Marike Laht, makes the museum's mobiles for weddings and different kinds of decorations for various events throughout the year, such as at Christmas and Easter. The Christmas mobiles are decorated with red tufts and the Easter mobiles with coloured eggs and feathers.

In Estonia, reed has also been used as stuffing for dolls. The reed knots can even be used as beads. Inside their houses, Estonian families have traditionally used reed mats to cover bare floors and walls, and outside as wind protection, scarecrows and for protecting apple trees.



Part V

Burning to Know



Turning reed into bioenergy

The long and winding road from beach to boiler

Eija Hagelberg, M.Sc., Project Planner, Southwest Finland Regional Environment Centre
Sami Lyytinen, M.Sc., Project Manager, Turku University of Applied Sciences

Our shoreline is covered by a thick blanket of reed beds, which have, so far, remained an unused source of energy. Being a rotting stationary biomass, reed beds reduce water quality, deplete oxygen supplies in water and release methane into the atmosphere. The expanse of reed beds also has an adverse effect on landscapes and jeopardises nature's biodiversity. Looking at our shorelines, many people have wondered whether the reed beds could be utilised in some way. Could reed beds be used to provide bioenergy?

In Finland a hectare of reed generates approximately 5 tons of dry reed material. The fuel value of dry reed is about 4.5 MWh/t, which means that the annual energy potential of reed beds is more than 20 MWh per hectare. This corresponds to the heating needs of an average-sized family home. There are 30,000 hectares of reed beds on the shorelines of Southern

Finland. Could some of the fuel needs of homes, agricultural buildings and energy installations be met from the utilisation of reed beds in the future?

When dry, reed is very light and therefore, without preliminary treatment, its transportation costs are high. Reed could be used as an additional local source of energy in coastal areas and, if pre-treated, also further afield.

Reed has been used to provide energy in various parts of Europe, such as Estonia, Finland, the Netherlands, Hungary and Romania. The methods have been found to be good in theory and they have provisionally been introduced, but not on as large a scale as they should be. The bioenergy sector continues to develop and new applications are invented for other sources of fuel. It is already possible to apply some of those solutions to reed and, if the opportunities afforded by reed become better known, its use as a source of bioenergy may take off quickly.

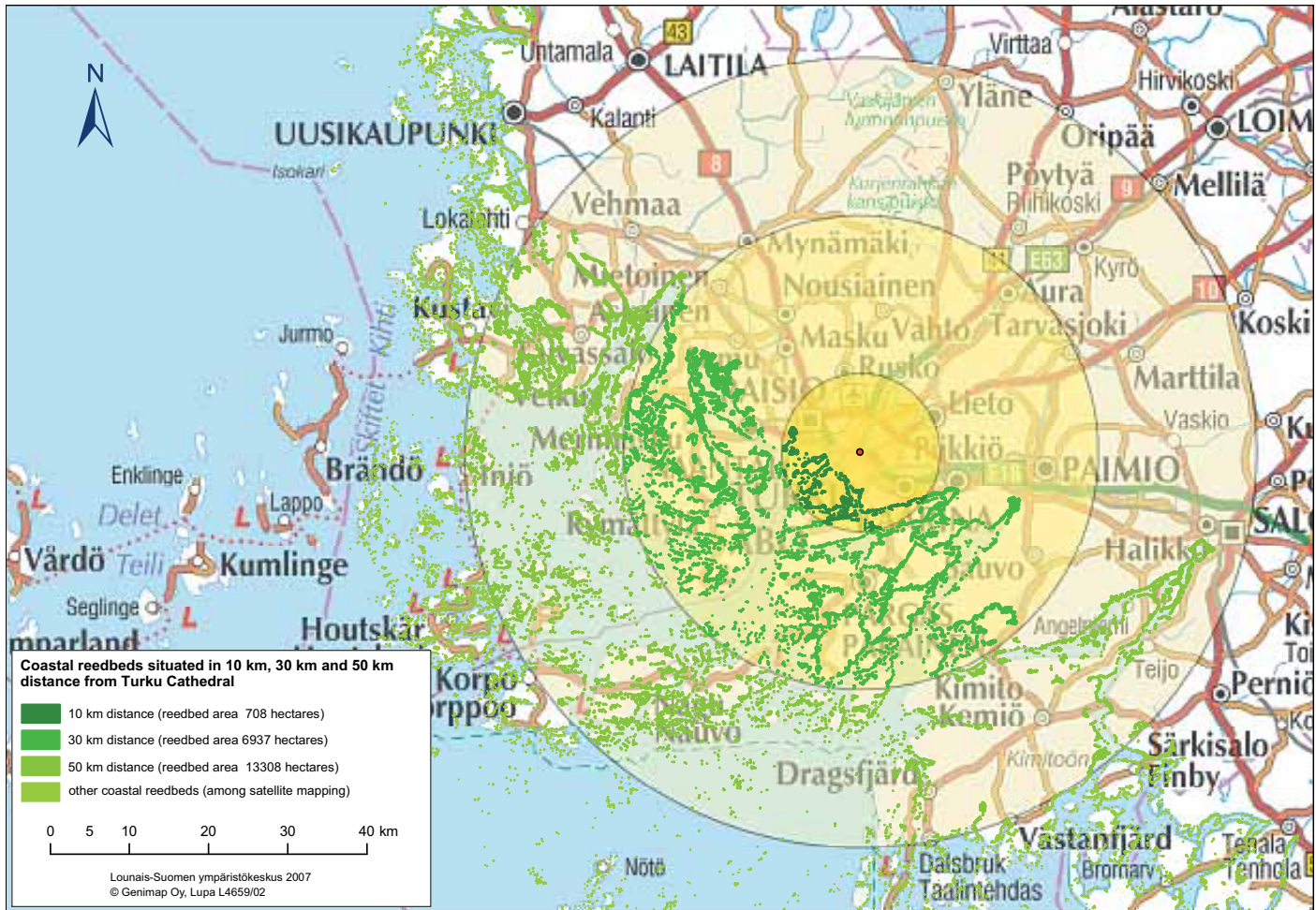
The properties of reed as an energy plant closely resemble those of Reed Canary Grass (*Phalaris arundinacea*). Reed Canary Grass is increasingly grown as an energy plant in the fields and former peat extraction areas of Central Finland. Unlike Reed Canary Grass, Common Reed does not need to be fertilised. Reed is more productive than Reed Canary Grass, and its ash melting point is higher. Reed has not been tried in field cultivation, nor has it been grown in the former peat extraction areas. Before starting to cultivate reed, a practical solution should be found for the use of the existing reed beds, because this biomass is rotting away from one year till the next while waiting to be used. Can we afford this kind of wastage in the future?

So much reed: when and how to collect it?

Reed grows in almost all of the shallow shore areas. It borders the shoreline as a thin belt and fills the inlets, particularly in shallow open waterways. According to recent surveys, there



An aerial photo from Salo, Halikonlahti Bay, Southwest Finland. The photo depicts a typical southern Finnish seashore: a broad reed belt of approximately 100 metres covers the shallow shoreline. Inhabitants find this kind of reed bed quite distracting as the view to the sea has disappeared. This kind of seashore could probably be utilised for reed harvesting for energy use. Photo: Lentokuva Vallas Oy.



Coastal reed beds within 10, 30 and 50 kilometres of Turku Cathedral. Map: Teijo Salmi, Southwest Finland Environment Centre.

are 13,000 hectares of reed growing within a 50-kilometre radius of Turku Cathedral.

Despite looking fairly similar everywhere, reed beds in different locations are not all the same; reed grows in different kinds of substrates and in varying moisture conditions. Some reed grows in water, whereas some grows on almost dry land, on sandy lake or sea bottoms, in bottomless sludge, along ditches and even in bogs. The quality of reed varies in different shore zones and in different kinds of substrates, and its biomass may vary greatly depending on the location. Different locations set their own challenges for the utilisation of bioenergy; it is difficult, or impossible, to use the same equipment in all reed beds.

Reed can be collected for bioenergy throughout the year.

During summer, the green reed is ideally suited for the production of biogas and biofuel, whereas the reed collected in wintertime can be burned in boilers.

If collected early in the summer, reed can regress effectively or even disappear altogether for a few years from a location. If collecting in the summer, it should also be borne in mind that other water plants may rapidly replace reed. Reed may be replaced by plants that are more troublesome and more difficult to remove. On the other hand, if reed is wanted to use as biogas material, the harvesting should be done on different years in various places, not in the one and same place yearly, otherwise the material will disappear. Collecting reed in late summer is the best way remove nutrients.

In Estonia it has been observed that winter harvesting leads

to reed beds becoming lower and thinning out. Winter cutting does not destroy reed beds as extended summer cutting does. Winter cutting removes old reed from the previous year, but the new green reed grows back at the start of the summer, unless its roots have been badly damaged during winter cutting.

Reed is at its driest during late winter, when its moisture may drop by 15%. This is when it is best suited for construction and for bioenergy. Even though the moisture content of winter reed does not cause a problem, it is worth remembering that reed contains more moisture in the morning than in the afternoon. In order to secure the best quality building material or energy source, the reed should be cut in the middle of the day when the sun has dried the reed beds slightly. Winter

cutting is also useful if reed is being cut for bioenergy because reed's chlorine and alkali content, which is so detrimental to burning appliances and processes, is then at its lowest.

Mild winters and late winter sun make reed harvesting on ice a very risky business, with only a few weeks of effective harvesting time each winter. An ideal harvesting machine would both float on water and move on land, in soft sludge, and on ice. According to observations made to date, the best harvesting machine for late winter harvesting of reed is a machine with a wide caterpillar tread. Another good option is a lightweight cutting machine with low-pressure tyres, such as a Seiga, which is used for instance in Estonia for collecting reed for construction purposes. Technical solutions for the collection of reed for energy uses remain absent, however.

It is possible to collect reed with traditional agricultural machinery if the ice is thick enough, or if the collection is undertaken in a hard-bottomed reed bed during a dry period. The majority of reed beds in South Finland grow in soft-bottomed locations, and ordinary agricultural machinery is not enough on its own, unless the bottom of the reed bed freezes over. In open water, the ice sheet may grow to be more than 50 centimetres thick in South Finland during a cold winter, but in a reed bed the ice may still not carry the weight of a harvesting machine because the rotting stationary reed acts as an insulating material. The surface of the water may also vary during the process of freezing and, therefore, influence the formation of ice. If the freezing occurs during high tide and the water level drops afterwards, a layer of air remains within the reed bed between the ice and the land. If the reed is cut regularly during winter, however, the rotting layer of insulation gets thinner year by year and the ice in the reed bed gets stronger with time.

The conditions for reed harvesting can be challenging and can contain risks: Winter storms can disturb harvesting and, in the worst instance, can even destroy entire reed beds. For this reason, reed should not be used as the only source of energy, but it can be used as an additional energy source, particularly during winters that offer the right conditions for harvesting.

Reed cannot be harvested by anyone, and particularly not from anywhere. The person harvesting the reed must always have permission from the owner of the reed bed. In the case of nature conservation areas, the person intending to harvest should get in touch with the environmental authorities to ensure that there are no objections to harvesting in that particular area. There may be other restrictions, which will become



Winter harvesting for construction material in Saaremaa, Estonia, in March 2006. Harvesting machines with low-pressure tyres can move on soft snow and ice even when fully loaded, while human feet would sink on the same surface. Photo: Eija Hagelberg.



apparent when talking to landowners and local authority representatives.

Several uses

The way in which reed is used for energy depends on the time of harvesting and the boiler used. During summer, the green, wet reed is suitable for producing biogas and biofuels. Reed harvested during winter can be burned in different types of boilers, for instance as shreds (mixed with woodchips), or as pellets, briquettes or whole bales. Ashes generated by burning can be spread on fields as a fertiliser.

As a mixed fuel together with woodchips, peat or cereal dust.

If reed is finely shredded and mixed with woodchips, it works well as a fuel in modern boilers. The key thing is to chop the reed short enough and mix it with the other material in the correct ratio for the boiler type and the intended burning process. Reed can also be mixed with cereal dust and peat. Studies conducted on Reed Canary Grass can be adapted to Common Reed.

Whole bales

Using straw bales as a source of energy is common in Denmark, and there are all kinds of boilers available for different



Winter reed harvesting by tractor in Hamina, Southeast Finland, in February 2006. The ice was very thick and there were no problems with the tractor. Photo: Teemu Kettunen.

uses. Perhaps the most cost-effective way of burning reed is to burn it in bales; the reed then needs very little processing. The modern straw bale boilers, in which the bales are shredded and then fed into the boiler by blowing them into the flames, may also be suitable for burning reed bales. These boilers could also cope with the amount of ash generated by burning reed.



Chipping dry reed for burning tests in Halikko, Finland, in May 2007. Reed can be very viscous, and it can be difficult to chip it into very small pieces (under 5 cm) with the common wood chipping machinery. Photo: Eija Hagelberg.



Reed going to a boiler together with woodchip in Perniö, Finland, in June 2007. Long pieces of reed are not a problem in large-scale power plants like this one, but they can get badly stuck in small-scale boilers. Photo: Eija Hagelberg.

Pellets

The best thing about tightly compressed pellets is their energy density and their ease of handling. It is easier to transport compressed pellets over longer distances than shredded reed, and the transport costs do not become such a constraint. Pellets require less storage space and are ideally suited for heating residential properties. The popularity of wooden pellets is growing steadily in Finland, and alternative pellet materials are actively being sought. Reed may be one such material, because reed harvested in winter is dry enough to be turned into pellets.

Briquettes

Briquettes resemble pellets; they have been compressed into small blocks of reed by a method of compressive force. The problem with briquettes is the accumulation of ash that collects on top of the briquettes, which affects their burning. This is not a big problem in modern woodchip boilers because the air that is being blown into the boiler will also get rid of the

ash from the surface of the briquettes. Reed briquettes work in the same way as wood briquettes do. Compared to pellets, it is sometimes easier to make briquettes, but their market is more limited and they attract a lower price.

Biogas

Hay and manure are used as energy in biogas installations elsewhere in the world, and increasingly also in Finland. Common Reed is also suitable for the production of biogas. Reed that is to be turned into biogas must be collected in summer, when the plant is green. The byproduct of the biogas production process is pure fertiliser, which can be spread on the fields. Besides providing energy, this process will return nutrients, which were washed from the fields into the shoreline waters, to the fields. When planning new biogas installations, the availability of reed should be considered when selecting the location for a plant. Suitable locations for biogas installations are areas with plenty of reed beds, or areas in which the decision has been made to reduce the number of reed beds.



Cutting reed with a boat-mounted mowing machine is a quick job, but gathering in the cut material is another matter. This is a test to gather mowed reed using surface oil dispersal booms in Mietoinen, Finland, in June 2007. This boom system was a little bit too heavy-handed. Photo: Helena Särkijärvi.



The entire chain is important

The use of reed as an energy source may be cost-effective and useful, or it may be too expensive, labour-intensive and waste energy. In order to maximise the use of reed, an optimal user chain must be established from the point of collection to the eventual use as an energy source. It is not sensible to burn reed to create heat if the chain of collection itself uses more energy than the plant actually produces. An optimal chain requires the collection to take place locally; it is not sensible to transport the reed for dozens of kilometres from one place to another. There is no single optimal chain, however: the user chain is affected by factors such as the size of the incinerator, the size of the harvesting area and the machinery used for harvesting.

The following section introduces three possible models of chains for the collection and use of reed, which could be used as the bases of cost-effective reed utilisation:

Chain model 1.

Shoreline of a summer cottage -- agricultural contractor -- pellets or briquettes -- sale to owners of holiday cottages

This chain could work well in areas that are full of holiday cottages situated close to reed beds. In this model, an agricultural contractor buys a reed-harvesting machine and signs a harvesting contract with the owners of holiday cottages in the vicinity. The contractor would remove reed from the shoreline of the holiday cottages in late winter, potentially including larger inlets that are in the vicinity. The contractor would transport the reeds to a covered store and chop them or press them into pellets or briquettes. These he would sell to nearby residents to be burned in pellet-burning fireplaces to generate heat. This would enable residents and visitors to holiday cottages to enjoy heat generated by a plant, which they usually hate. This would also open up the landscape from their cottages and remove the rotting reed mass from their shorelines. Whilst developing the model and considering the price of reed pellets and briquettes, it is useful to ask whether the holiday cottage owner would be prepared to pay a slightly higher price for his reed pellets than he currently pays for his wood, which does nothing to clear his shoreline.

Chain model 2.

An extensive harvest to promote environmental care or leisure use. Mass burning in a large-scale incinerator just to dispose of the materials collected.

In the vicinity of towns and tourist attractions, reed may be viewed as a factor affecting the quality of life and leisure use of the area, resulting in a decision to reduce the number of reed beds. The owner or manager of an area (such as municipality, state, business, parish, jointly owned property, environmental care project, etc.) can employ a specialist contractor to come and harvest the reed. If no cost-effective energy use can be found in the vicinity, the reed can be burned in a large-scale power plant with other types of biomass. The price paid by the energy company for the fuel is low compared to the cost of harvesting the reed, but it supports the greater aim of removing the reed.

Chain model 3.

Harvesting with agricultural machines during a cold winter, or with a reed harvester -- burning with wood chips in his own boiler or selling it to neighbours

A farmer with suitable machinery intended for the harvesting of hay or with a machine (possibly home-made) that is suitable for collecting reed for energy use is able, depending on the strength of the layer of ice, to harvest reed from ice in late winter. Old tractors are often lighter and farmers dare to use them on the ice more readily. In this model, the reed is processed at the time of harvesting (it is shredded or baled on the ice), and then used in the same way as Reed Canary Grass (i.e. it is mixed with woodchips and burned). The farmer could sell the material to other woodchip-burning farms and greenhouses in the vicinity, or use the material in his own woodchip-burning boiler.

Other uses for reed collected in winter

The same machinery that in wintertime collects reed for energy use can also collect reed for other uses. Mixed with peat, reed can be used as litter for cattle in cowsheds. Reed is an excellent covering material for strawberry fields and elsewhere in the kitchen garden; it keeps the weeds at bay and, thanks



to its pH value, is a much better option for vegetable patches than coniferous chippings. As a vegetable patch covering, reed also decomposes relatively slowly. Besides being used to cover plants, reed can be used to provide insulation for gardenplants. In former times, it was used to cover seedlings, for instance.

Involving the community in reed harvesting

Local participation is a big plus and clearing up the waterways gives added value to reed harvesting and utilisation. In particular, winter harvesting of reed beds benefits the surrounding area in a number of different ways. For this reason, local people should be encouraged to participate in the harvesting of reed.

So far there have been no subsidies for reed harvesting, but in the future the situation may change. For instance, energy plant subsidies or environmental subsidies should also be made available for the harvesting of reed beds. As well as of-

fering financial subsidies, society could support the harvesting of reed beds in other ways. Reed harvesting and reed bed management could be used to offer the long-term unemployed work in the environmental care sector. There are examples of this model in existence; for instance, in South Savolax this model is used to organise the summer harvesting of reed.

By supporting harvesters of reed beds in different ways, reed could be turned into a competitive option for many different uses. It would be an environmentally friendly option for two reasons: it is an ecological, natural material, and its removal improves the environment.

Time to take the next step

Our experiences of the energy use of reed are promising. This stubborn plant sometimes gives problems to modern man, who is used to effectiveness in everything, but those problems can be overcome. The facts must of course be acknowledged,



These kinds of harvesting machines can also work on soft surfaces. More research and development should go into these kinds of devices. Photo: Sami Lyytinen.



and there are bound to be challenges in the beginning, starting with the fact that the substrate of reed is often problematic for harvester. At this stage we should not just wait for cold winter weather and thick ice to be able to use reed for energy. Instead, we should develop machinery and the harvesting chain in such a way that it will be possible to harvest even during unseasonally warm winter weather. The starting point should be to try to ensure the utilisation of reed as a local, additional source of energy, to improve the cleanliness of our waterways and to pay attention to other environmental issues. It is easy to turn reed into energy, and it grows back before the next harvesting season.

References:

- Pitkänen, T. 2006. Missä ruokoa kasvaa? Järviruokoalueiden satelliittikartoitus Etelä-Suomen ja Viron Väinameren rannikoilla. Turku University of Applied Sciences publications, Puheenvuoroja vol. 29. Also available in internet www.ruoko.fi/julkaisut.
- Isotalo, I., Kauppi, P., Ojanen, T., Puttonen, P. & Toivonen, H. 1981. Järviruoko energiakasvina. Tuotosarvio, tekniset mahdollisuudet ja ympäristönsuojelu. Vesihallitus, Tiedotus 210. Helsinki.
- Reed strategy in Finland and Estonia – Interreg IIIA. www.ruoko.fi [ref. 20th May 2007.]





Reed as energy resource in Estonia

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Wider implementation of renewables is supported by the governments of all countries, or they at least state it, while in many countries the respective economical and political support systems have been established already. In Estonia biomass and wind are considered to be the most important renewables. These resources and power from flowing water (hydropower) have been used in our region for centuries already. Also natural, highly productive crops of grasses should be taken into account as energy biomass that can be upgraded by technological conversion to be used as a fuel. In Western Europe similar work started after the so-called first energy crisis in the 70ies of the last century.

Location of reed beds and reed resources in Estonia

The total area of Estonian reed beds is estimated ~26 000 ha (Kütuse- ja energiamajanduse riiklik pikaajaline arengukava aastani 2015) according to the map of wetlands of Tartu University (TU) Department of Geography. Mostly reed grows in the wetlands, to smaller extent also shrub willows and cattail, and in between there are patches of open water.

Up to now the potential of biomass in the wetland plants as an energy resource (fuel) has not been taken into account, although it is quite promising due to the high yield of the plants growing there and their relatively high energy content. The importance of wetland biomass as an energy source is not limited with the economic effect only,

but could contribute significantly to the environmental protection, developing of natural landscapes and improvement of employment rate in the rural regions all over Estonia.

The biggest reed beds in Estonia cover almost 3 000 ha in the Matsalu Wetland. The reed beds there are among the largest in Europe (Mets, Ü 2005). The Mullutu and Suurlahe (so-called internal sea or former bays with the free connection to the open sea) reed growing areas on Saaremaa cover about 2 200 ha. The Võrtsjärve reed beds stretch to almost 1 200 ha; in Lake Peipsi (together with Lake Lämmijärv and the parts of Lake Pihkva that belong to Estonia) the area of reed beds is almost 930 ha. On the island of Hiiumaa in the Käina Bay

County	Reed beds area, ha	Harvestable area, ha/y	Yield, t/ha	Energy content, GWh/y	
				Theoretical	Realistic
1	2	3	4	5	6
Harju	265	130	9,3	9,71	4,76
Hiiu	2685*	1300	8,0	84,63	40,98
Saare	7387*	3700	4,5	130,97	65,60
Pärnu	1343	670	6,0	31,75	15,84
Viljandi	577	290	6,3	14,32	7,20
Valga	491	250	6,5**	12,57	6,40
Võru	497	250	6,5**	12,73	6,40
Lääne-Viru	379	190	8,5	12,69	6,36
Tartu	4201	2100	4,9	81,10	40,54
Põlva	170	90	9,7	6,50	3,44
Lääne	8000*	4000	6,0	198,12	94,56
Total	25995	12970		595,1	292,1

Table 1. Energy content of reed resources in the Estonian wetlands.

For the providing sustainability of reed beds, it is not reasonable to cut reed in the same areas each year and harvesting in all the areas is also not realistic due to unfavourable environmental conditions and ownership relations. Based on the above and considering the corrected areas of reed beds (Saare, Hiiu and Lääne Counties) as a result of crop yield measurements in some counties, the reed resources, which could be used for energy production were established (Table 1).

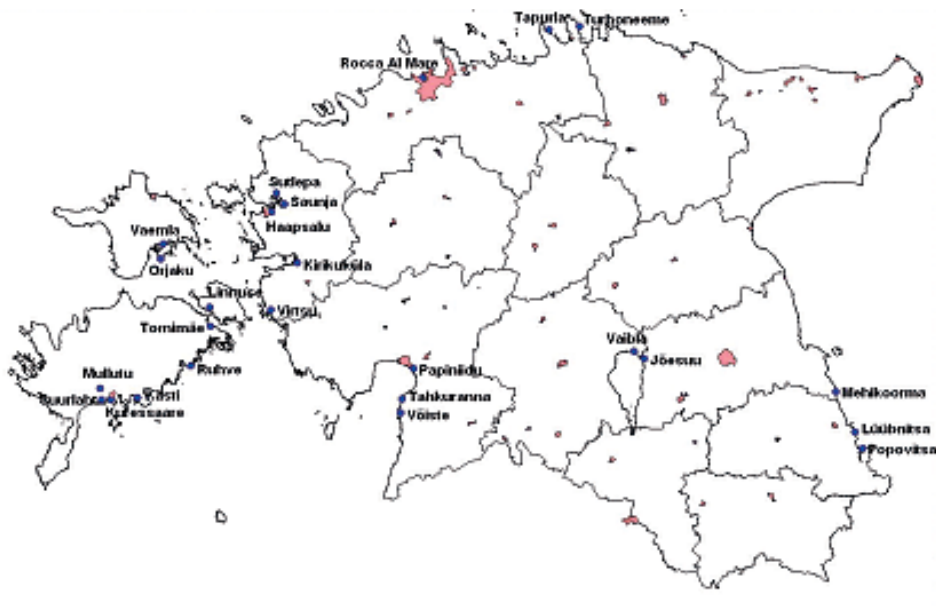
1. The counties with no reed beds or their area being less than 100 ha have been omitted.
2. According to the winter measurements in 2006, for the moisture content of 20% the average energy content of reed is 3.94 MWh/t (TUT TED).
3. Column 2 shows the estimated areas of reed beds in the wetlands of counties.

** The average yield in Estonia according to the winter measurements of 2006 and 2007. In other counties the real average data of yield measurements (TUT TED) have been used.

The biomass yield per hectare of reed beds depends on several factors, as for example the location of reed bed, soil content, climatic conditions of the year, availability of nutrients, etc. Some earlier studies show that in natural wetlands, in the coastal areas at seas and lakes the annual growth of dry matter is 1–1.5 kg per m². The crop yield in the reed beds of Matsalu National Park has been estimated by Asko Noormets (1994) and that in Lake Peipsi by

The TUT TED has arranged measurements of reed yield in 27 different sites of 9 Estonian counties total, both in the spring-winter and summer period in 2006-2007 (Fig. 1). The results of yield measurements are summarized in Table 2. In Estonia the reed beds could be harvested on the area of about 13,000 ha. According to Table 2, the energy content of reed harvested from this area would be about 300 GWh. It would not be realistic that the total amount could be used for energy production, because the building material industry competes for the same raw material (roof cover, insulation panels, etc.).

In Sweden the high yield reed beds have given 5-10 t/ha of dry biomass harvested in winter. In the bogs at the Danube River 3-30 t/ha of reed has been harvested in winter (Isotalo et al. 1981).



Period of measurements	Average yield, reed fuel as received t/ha	Average yield of dry matter, t/ha	Average moisture content of samples %
<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>
Spring-winter 2006 (02-04)	8,06	6,30	20,52
Summer 2006 (08)	19,98	8,55	57,67
Winter 2007 (02-03)	9,09	6,59	26,39*

Table 2. Average yield of Estonian reed beds according to the measurements made in 2006 and 2007 (TUT TED).

Remarks:

1. The two- year-average yield in the winter period is 6.45 t/ha.
2. The yield of dry matter is 32.5% or one third higher for summer samples than that in winter samples. The main reason lies in the fact that the actual amount of dry biomass in the winter harvest is smaller (the leaves have fallen and the cutting height is higher due to the ice and snow cover).

* In 2007 in places the weather was rainy and snowy and the moisture content in reed higher than usually during the industrial harvesting. As an average for years, the reed with the moisture content not exceeding 20% can be harvested in the spring-winter period (Fig. 2).

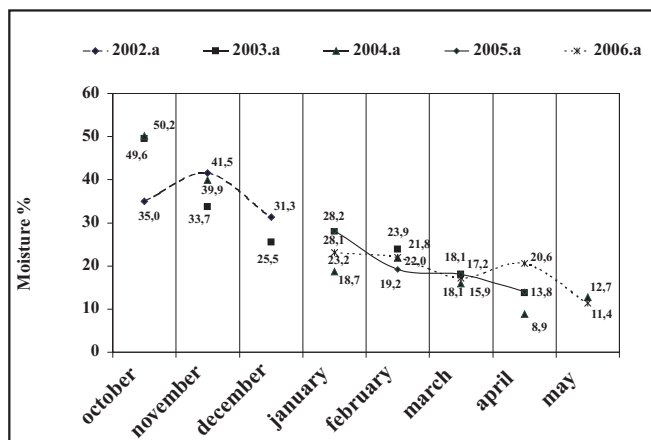


Fig. 2. Moisture content dynamics of reed from October till May 2002-2006 (TUT TED).

Common Reed and Cattail are also grown in artificial wetlands or wetland treatment systems where the wastewater from settlements and farms is treated and constant influx of nutrients is provided. Their production in the systems could be twofold compared to natural wetlands.

According to some data, developing of 0.1 Mha of artificial wetlands (Kütuse- ja energiamajanduse riiklik pikaajaline arengukava aastani 2015) with the cattail plantations that would yield annually 6.1 PJ or 1.7 TWh of primary energy (the average dry matter yield in winter is 4.3 t/ha and energy content 3.9 MWh/t for the moisture content of 20%, by the TED data) can be considered realistic. When considering the higher reed yield in winter, it would be expedient to build wetland treatment systems with these plants, because in this case the energy content of reed harvested in a year would be 3.5 TWh (the estimated yield at least 9.0 t/ha).

In the neighbourhood of Viljandi at the well-spring of Tännassilma River the grassland vegetation has been replaced by monocultures as thick Cattail beds and it works as a wetland treatment system. The concentration of surface phytomass (biomass) of vegetation in the Tännassilma Wetland is 2.1 kg/m², in the Kõo Rural Municipality 1.82 kg/m² and the surface biomass concentration of plants in the Häädemeeste Wetland is 1.61 kg/m². Based on this data the annual energy resource of Cattail in the above areas could reach 4.4 GWh (Maddison, M. 2003).

In Estonia building of wetland treatment systems could have high potential, first of all in small villages and sparsely populated places where there is sufficiently available land for the construction of the system and density of population is low. Usually 10 m² of wetland treatment area per inhabitant is considered sufficient. In Estonia there are 939 villages, hamlets and settlements where the population remains in the limits of 100 – 2 500 and their population in total is estimated 400,000. If to solve the wastewater treatment problems



based on wetland treatment systems, we would need 400 ha of wetland treatment systems where the harvested yield of reed could reach a minimum 3 600 t/y and maximum 8 000 t/y. The primary energy content of this amount of reed is 14.2 or 31.5 GWh, respectively. This amount is scattered all over Estonia and is feasible to be used it in the vicinity of production area.

Availability of reed resources – human factors and natural factors

The yield of reed fluctuates in accordance with the natural conditions, both in the period of growth and drying. In the period of intensive farming (70ies and 80ies of the last century) when a lot of nutrients fell accidentally in the wetlands, and on the other hand, pasturing of cattle in the coastal meadows decreased (this goes on presently also), the reed beds expanded rapidly.

Since today agriculture is developed mainly in the regions of high soil fertility, the nutrients leached in rainwater occur less in the wetlands and reed beds. During the last decade reed has been cut for building material. Due to constant harvesting and reduction of outside nutrient input in reed beds, the yield of reed beds is gradually lowering. This trend has been mentioned by the reed harvesters who cut reed for roof covering. In order to avoid the phenomenon, the field rotation method should be introduced (similar to crop rotation in farming). The reed beds should be cut by small patches where certain harvested patches could recover for some years. This technology is in good conformity with the environmental requirements (see below). Undoubtedly, this reduces the annual amount of reed mass yield and is more inconvenient for harvesters, but it is more sustainable and nature friendly at the same time.

The winter floods, storms, waterbodies frozen during high waters and snow storms may damage the reed growing areas a great deal. The winter storm in 2005 with the concurrent flood destroyed reed on thousands of hectares with ice breaking up and drifting in 2007 several reed beds were destroyed over extended areas.

The dry reed can be cut in the sea and lakes (in water) only in winter when the thickness of ice on the waterbodies is sufficient to carry heavy machinery. Harvesting on coastal meadows with soft soils is possible only when the surface is frozen. When the ice is formed early with high waters (autumn-



Thinned out reed bed on the island of Muhu, Estonia as a result of long-term winter cutting through years. Photo: Ülo Kask.



The storm has broken reed. Kasti Bay, Estonia, 2006. Photo: Ülo Kask.



The reed bed destroyed by drifting ice. The Sututõ Bay, Estonia, 2007. Photo: Ülo Kask.

winter period) and will not develop sufficient thickness, in spring when the time is most suitable for the fuel reed cutting, the water table has lowered and ice may break up under the weight of reed cutter. In places deep snow on reed beds could also prevent reed cutting.

Also thick snow that has fallen on thin ice may prevent formation of necessary ice thickness to carry the weight of cutting technology. There are sites where the heat escaping as a

result of decay processes in the mud of reed beds in the sea or lakes prevents formation of ice thickness sufficient to carry the weight of cutters. According to the data by Finnish researchers, ice with the thickness of 20 cm can carry a 2.0 ton vehicle, 25 cm ice layer can resist 3.0 tons and 30 cm thickness of ice can carry up to 4.5 ton vehicle (cutter, tractor, baler, etc.). The machinery for reed cutting used by Finns at their reed cutting tests weighed 2.5-3 tons (Isotalo et al. 1981).

In several reed growing areas the cutters' work could be complicated by stones in the soil. In the reed cutting tests in Finland, Liminganlahti the stony surface became crucial, because this was the reason why the cutting blades and technical units of mowers were often broken.

Due to constant cutting and lower outside input of nutrients in the reed beds, the yield of reed beds decreases gradually. Therefore harvesting of 100% and in the worst case even 10% of necessary fuel reed cannot be guaranteed at each site each year.

In spring during the Kääri Bay reed cutting has to be completed already in the middle of March and cutting should be carried out by patches so that there will remain sufficient free and sheltered areas for birds. In some reed beds any economic activities and reed harvesting is forbidden (reservations, at Matsalu 500 ha).



High snow heaps in the reed bed. Photo: Ülo Kask.



Reed properties and upgrading for the use as a fuel

Much less biomass that can be used as a fuel grows in natural wetland plants than for example, in the wood from forests that can be burned, or energy wood cultivated in the fields and other energy cultures. However, the properties of reed as a potential fuel have to be learned, because the way of handling reed for burning, lifetime of combustion technology (fouling, corrosion), combustion regimes and environmental impact (emissions) depend on these properties. The reed combustion characteristics vary to some extent depending both on the site of growth (on the shore of sea or lake, river deltas, wetland treatment systems) and seasonally (harvested either in summer or winter). The most significant combustion indices are moisture content, heating value, content of fly matter, ash content and composition have been determined in the TUT TED.

Moisture

The content of moisture reduces the heating value of fuel essentially, increases the volume of flue gases, and deteriorates ignition and combustion. The moisture content of energy reed depends significantly on the season (Fig. 2) while reaching 18–20 % moisture content suitable for combustion in natural conditions only in March/April; some years even earlier, already in January/February. This allows concluding that the best quality reed for using as a fuel could be harvested in average 90 days a year (from January to March).

Calorific value

The reed calorific value Q_b was determined in the calorimetric bomb (Table 3). In the table also the upper Q_u and lower Q_l calorific values are given. When flue gas leaves the combustion unit at the temperature higher than the condensation temperature of water vapour, the lower heating value is used. In the engineering and economic calculations it is more convenient to use the volumetric energy density of moist fuel as received at 20 % moisture content (E_{20}) kWh/kg, kWh/m³ or MWh/m³, MWh/t (last column in Table 3). The calorific value depends on the amount of combustible matter and its chemical composition (Table 3).



Energy reed (reed height 5-10 cm). Photo: Ülo Kask.

Parameters	Range		Average	
	Winter	Summer	Winter	Summer
q_b	18.62–19.16	18.33–18.77	18.92	18.51
$q_{gr, d}$	18.62–19.16	18.31–18.75	18.91	18.49
$q_{net, d}$	17.48–18.01	17.02–17.44	17.77	17.21
$q_{net, 20}^*$	13.68–14.86	13.16–13.49	14.17	13.31
$E_{20}, \text{MWh/t}^*$	3.80–4.13	3.65–3.75	3.94	3.70

* at 20 % moisture content

Table 3. Calorific value of dry fuel reed, MJ/kg (TUT TED).



nt o o ition

The organic matter of fuel reed (OM) is mainly composed from carbon (C), oxygen (O) and hydrogen (H) similar to wood fuel (Vares, V. et al. 2005), but the oxygen content in the OA of reed as an annually re-growing plant is somewhat higher and that of carbon and hydrogen a bit lower. The content of nitrogen (N), sulphur (S) and chlorine (Cl) in the reed samples harvested in winter is low. The sulphur content of wood is usually below 0.05 %. The reed harvested in summer contains more nitrogen, sulphur and chlorine unfavourable for burning compared to the winter harvest. (Table 4)

ont nt n o o ition

The ash as a solid residue formed by combustion plays an important role in the selection and running of combustion equipment and its auxiliary devices. The ash content of reed harvested in winter is 2.1–4.4 %, in average 3.2 %, but for summer harvested reed it is significantly higher being 4.1–6.2 %, in average 5.4 %. The data on the chemical composition of reed ash is shown in the table and figures (Table 5, Fig. 3 and 4). Other components could be P_2O_5 , SO_3 , CO_2 and many others, but they were not determined separately in the TUT TED. The range means that samples from 14 different growing sites were analysed and each had different component content.



Element	Range		Average	
	Winter	Summer	Winter	Summer
C	46.96–48.34	46.13–47.11	47.5	46.5
H	5.50–5.60	5.93–6.42	5.6	6.2
O	42.75–43.84	39.7–42.2	43.3	40.7
N	0.23–0.34	0.57–1.17	0.3	1.0
S	0.03–0.09	0.12–0.45	0.04	0.2
Cl	0.05–0.18	0.28–0.48	0.1	0.4

Table 4. Elemental composition of dry fuel reed, % (TUT TED).

Component	Limits		Average	
	Winter	Summer	Winter	Summer
SiO_2	65.34–85.50	25.90–48.33	77.77	37.10
Fe_2O_3	0.13–0.84	0.17–1.69	0.29	0.70
Al_2O_3	0.1–1.69	0.11–1.12	0.57	0.61
CaO	3.07–7.27	4.02–11.53	4.42	6.84
MgO	0.4–1.45	1.87–4.88	1.22	3.33
Na_2O	1.96–9.05	0.87–10.98	3.19	3.61
K_2O	0.99–5.69	14.89–31.33	4.26	24.77
Ohter	1.57 – 19.4	17.28 – 33.5	8.28	23.04

Table 5. Chemical composition of reed ash at 550 °C, % m (TUT TED).

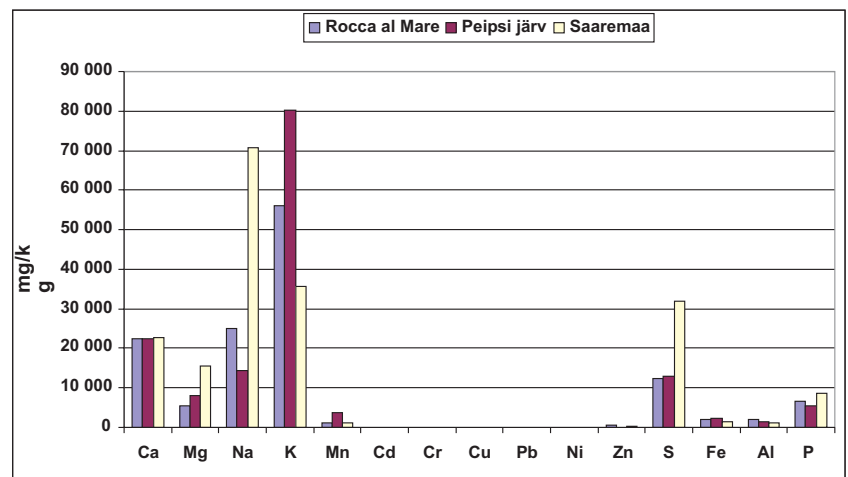


Fig. 3. Element content in the winter reed ash, mg/kg (ENAS Oy).

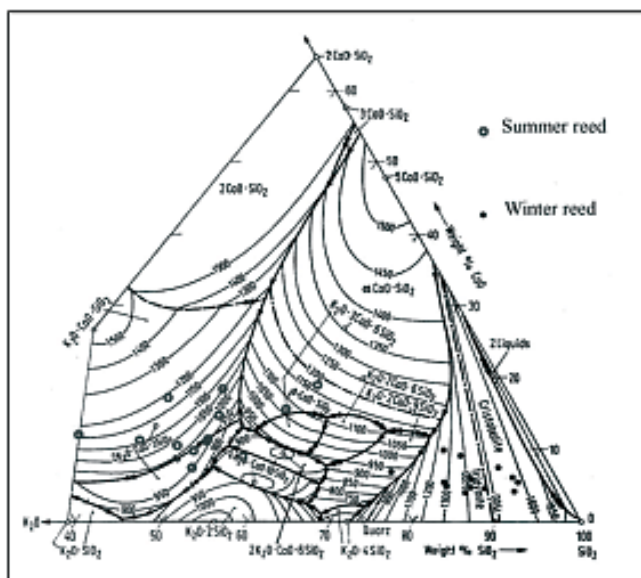


Fig. 4. K_2O - CaO - SiO_2 ternary diagram with solidus (initial melting) temperatures and composition of the different samples of summer and winter reed used in this study.

The chemical composition of reed ash for summer and winter harvests differs essentially for the content of SiO_2 and K_2O . The reed harvested in winter would be a much better fuel to burn in the combustion equipment from the point of view of ash composition. The ash of reed harvested and dried in summer contains in significant amounts alkali metals that influence both ash fusibility, formation of ash deposits on the heating surfaces and corrosion.

The ENAS Oy in Jyväskylä was determined the element content of winter reed ash (Fig. 3). The microelements are considered the elements the content of which is agreed to be below 1000 mg/kg (however, usually below 100 mg/kg).

Ash-fusibility (melting) temperatures

Table 6 gives the winter and summer reed ash-fusibility temperatures of some samples. It is important to note that the summer reed ash cone fused down at the temperature lower than 1 200°C, initial deformation took place at temperatures below 800°C (Table 6). On the other hand the ash of winter reed did not fuse down even at 1 350°C; only one sample showed evidence of the deformation at the temperature of only ~ 800°C. We can state that the average ash-fusibility

temperatures for summer and winter reed ashes differ for 200 K. This proves that the reed as a boiler fuel must be most definitely harvested in winter, when the nutrients and minerals have accumulated in the roots and leaves have fallen.

The ash-fusibility temperatures depend both on elemental and component composition. Often the ash-fusibility temperature is treated as depending on the total of ash alkali components or ratio of alkali and acid components. The ash-fusibility temperature depends also on the test environment: in the reducing and semireducing environment the fusibility temperatures are generally lower than in the oxidizing atmospheric environment.

The results of the ash chemical analyses have been entered in the ternary diagram (Fig. 4). Then it can be seen whether they match the place where the fusibility temperature is approximately the same as established by our test and whether the results are realistic and the rest of components that cannot be seen on the ternary diagram have strong influence on the ash behaviour in the furnace or not (e.g. 1% of some ingredient can influence the ash fusibility significantly).

It would be complicated to take into account the impact of all the components in the diagram and therefore the main components that are more significant were selected. The main components that influence the reed ash fusibility are SiO_2 , K_2O and CaO and that enables to consider the dependence of reed ash on these components in the ternary diagram as well (Fig. 5) (Paist, A. et al. 2007). The oxides of alkali metals K_2O and Na_2O , which have influence on the ash-fusibility temperature in combination with other chemical compounds bring down the ash-fusibility temperature in general.

The content of alkali metals in the reed harvested in winter is essentially lower than that of summer reed and therefore the fusibility temperatures are also significantly higher. The correlation between laboratory defined ash-fusibility temperatures and isotherms of ternary is quite good. The ash-fusibility temperatures of summer reed are significantly lower and therefore the danger of ash sintering and fusion by burning in the high-temperature flame is high. Also the danger of fouling heating surfaces with the ash particles and slagging grates is high. Thus the dried summer reed could be burned in a low-temperature furnace, but also in a bubbling fluidized bed furnace at the temperature about 850 °C.

The ashes formed by fuel combustion foul the heating surfaces with fly ash. The ash layer prevents heat exchange and may also accelerate high-temperature corrosion. The most well-known components that accelerate corrosion are the



compounds of alkali metals, chlorine and sulphur, for example pyrosulfates formed of the named compounds. This is why the corrosive impact of alkali metals and low content of sulphur on the boiler heating surfaces must be considered and an appropriate metal chosen.

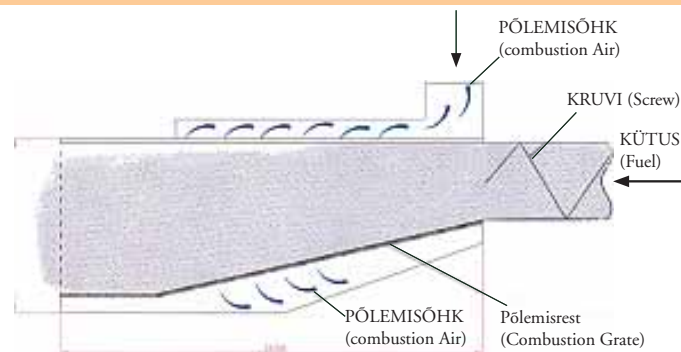


Fig. 5. Stocker burner elaborated in the TUT TED.

Fusibility characteristics of summer reed							
Samples from different places	I 06 01	I 06 02	I 06 03	I 06 04	I 06 05	I 06 06	I 06 07
Point of deformation (IT)°C	700	650	670	640	730	690	580
Softening temperature (ST)° C	990	1000	1040	960	1030	910	760
Formation of hemisphere (HT) °C	1130	1110	1120	1060	1150	1080	910
Flow temperature (FT)°C	1170	1130	1160	1090	1170	1120	990
Fusibility characteristics of winter reed							
Point of deformation (IT)°C	800	1040	1220	up to 1350 don't melt	790		1050
Softening temperature (ST)° C	1240	up to 1330 don't melt	up to 1330 don't melt	up to 1350 don't melt	1040		1200
Formation of hemisphere (HT)° C	1290	up to 1330 don't melt	up to 1330 don't melt	up to 1350 don't melt	1230	up to 1375 don't melt	1270
Flow temperature (FT)°C	up to 1340 don't melt	up to 1330 don't melt	up to 1330 don't melt	up to 1350 don't melt	1270	up to 1375 don't melt	1290

Table 6. Reed ash fusibility characteristics (summer, winter 2006).

ringu gr u r

The device that has been available for pressing reed pellets (photo on right) Agri 20 is made in the Republic of South Africa and when the mix of herbaceous biomass is used as a source material where 80% is Alfalfa (*Medicago sativa*) and 20% corn, the productivity remains in the range of 150-200 kg/h of pellets. The reed pellets were made with the diameter of 8 mm and length varying from 8 to 40 mm. The briquettes were pressed with the machine RL-50BM of the Taiwan SK Machinery Co Ltd. The length of reed briquettes (see photo on right)) was ~80 cm and diameter 50 cm. The reed briquettes expanded to some extent and cracked/ crumbled after exiting the machine. Hot herbaceous biomass briquettes should be packed air-tight as soon as possible before they cool down, so that they would not absorb humidity that would crumble the briquette.



Reed pellets. Photo: Ülo Kask.



*Reed briquettes on left and middle, wood briquette on right.
Photo: Teemu Kettunen.*

Reed combustion tests: Laboratory tests in the TUT TED

In the Boiler Laboratory of Thermal Engineering Department at Tallinn University of Technology combustion tests with the reed only and mix of reed and woodchips have been carried out since 2002. The pilot plant consists of a fuel hopper with mechanical blender from where the fuel is directed with auger feeders to the stoker burner (Fig. 5.), and boiler with the 250 kW nominal capacities (when the boiler is fired with woodchips). The first tests for the industrial combustion of reed were carried out in the Kalevi Boiler Plant of Kuressaare Soojus Ltd in the beginning of August, 2003. The reed residues of roof building material were transported to the storage facilities of the boiler plant. The residues were pressed and packed with the straw packing machine. In the fuel storage of boiler plant the residues were blended with woodchips.

The best for the pilot plant appeared to be manually crushed reed with the stem height of 4 – 7 cm. When using a blended fuel, it turned out that the higher the percentage of woodchips was in the mix, the more the auger feeder delivered fuel. The most optimal ratio of fuels and the corresponding capacity was obtained with the ratio where there were 5.5 mass units by weight of woodchips per one mass unit by weight of reed (1:5.5), or 1 m³ of reed was blended with 1 m³ woodchips. The moisture content of reed was 7 % and that of woodchips 50.5%. The boiler capacity up to 120 kW was reached. In

photo below we can see a rare ash cone left on the grate of stoker burner. At the same time the organic matter burns almost totally out (for ~ 98 %). When to burn reed only in the fuel wood and straw combustion boilers, problems may occur with ash disposal from the furnace due to its large volume and stable structure.



Reed ash residue after combustion. Photo: Ülo Kask.

Reed combustion tests: Pilot tests at Kuressaare Soojus Ltd

The first pilot tests were carried out in the Kalevi Boiler Plant of Kuressaare Soojus Ltd in the beginning of August, 2003. The reed residues of roof building material that were pressed and packed with a straw packing machine were transported to the storage facilities of the boiler plant. Their tying cords were removed and the grab crane blended reed with the mix of bark and sawdust. Then the mix was transported by a drag chain conveyor to the furnace. The height of reed remained in the range of 20 – 40 cm and its share in the burned fuel was about 7 % (by weight). The combustion caused no problems, only once too much reed occurred in the intermediate bin in front of the boiler that somewhat prevented fuel feeding to the furnace. The burned reed gave additionally 5.5 – 6 MWh of heat.

Two wood fuelled boilers have been installed in the Kalevi Boiler Plant (4 MW Saxlund and 6 MW DKVR). The boilers are fed from one storage, but due to the technical solution of the fuel feeding system, reed cannot be used as an ingredient to wood fuel when both boilers are run simultaneously. The

latter circumstances became evident at the follow-up tests in September. The problem was that the auger feeder that delivers fuel to the Saxlund boiler could not get enough fuel from the distributing bin located after drag chain conveyor.

The estimated height of reed should remain within 10 – 15 cm. The reed reserves in the Saare County are sufficient to supply fuel reed to the Kalevi Boiler Plant of Kuressaare Soojus Ltd in order to replace 10% of wood fuel with reed when a technically suitable and economically feasible logistic system for harvesting, shredding and burning reed will be found.

Combustion of upgraded fuel reed

Some reed pellets combustion tests were made in the TUT TED laboratory with the boiler Pelle (30 kW). In the burner IWABO Fastighet 30 the auger feeder pushes fuel onto the grate. The ashes of burned fuel fall onto the bottom of the furnace over the front edge of burner under the pressure of fresh fuel pushed on the grate. Three hours after the ignition of reed pellets the burning process slowed down due to the burner clogging (the same had happened earlier when the combustion of straw pellets was tested). Evidently the reason for burner clogging was a non-collapsing ash cone of ~ 100 g. When touching the ash with the hand, you got the sensation similar to kneading mineral wool. The average heat input of the boiler during testing was 19.2 kW and useful heat output ~17 kW. During the stable running of the boiler the mean flue gas temperature was 146.7 °C. The heating value of both reed pellets and briquettes at the moisture content of 8-9% was about 16.5 - 17 MJ/kg (energy content 4.6 – 4.7 MWh/t).

Throughout the test 12.6 kg of pellets with the moisture content of 8.68% were burned. The moisture content of raw material for pellets was ~12.0%. To the end of combustion process 358.7 g of ash was left and a part of it remained on the grate of stoker burner (27.9%), some on the ash pan of the boiler (67.1%) and 5.0% was carried to the convective flue gas duct. The unburnt part of ash or loss from mechanically incomplete burning was 0.33%. In the core of ash heap sintering could be observed that could have been fostered by the reflectory arch above the grate.

Conclusions drawn from the reed pellets combustion

The best way to burn the herbaceous biomass pellets would be in the stoker burner where the fuel is delivered to the circular

burner head (so-called pile burner grate) from below upward by an auger feeder. In this case the ash should fall homogeneously over the burner edge to the furnace. On the other hand, the share of unburnt fuel may increase. For burning herbaceous biomass the grate of pellet burner should be a travelling grate equipped with the mechanical ash handling system.

Reed briquettes combustion test

The reed briquettes were tested in regular ovens (combustion chamber without a grate). In one case the briquettes were placed on firewood billets and in the second case only reed briquettes were burned. The briquettes caught fire easily and burned with a vigorous flame. If the briquettes are piled in the furnace, the upper layer burns well, but since the formed ashes do not crumble, but preserve the framework, they bury the lower briquettes (also billets when briquettes have been piled on them). Then the ash layer prevents access of air to the lower level of briquettes (billets) and does not allow them burning out properly. When the briquettes are spread relatively homogeneously on the furnace floor, they burn out better, but not completely. Thus the fuel pile has to be stirred from time to time anyway.

As a conclusion we can state that it is rather inconvenient to burn reed briquettes in regular ovens (evidently in kitchen stoves too) since the fuel has to be stirred often and relatively high amount of ash is formed. In the future more attention should be paid on investigating the physical properties of the combustion process, and combustion technology for burning upgraded solid fuels of blended herbaceous biomass (dried, pressed).

Combustion equipment for heat production

The variety of equipment burning herbaceous biomass is rather wide and finding the suitable one depends much on which kind of fuel the user wants to burn, either:

- pressed (pellets, briquettes),
- packed (baled),
- crushed (shred).

For burning the pressed fuel traditional granular pellets or pellet burners and furnaces that match these burners are used. Usually the capacity of this equipment remains in the range that can be used for heating of single family homes or single buildings (10–100 kW).



In the combustion equipment for burning straw bales (straw packages), the bales of other herbaceous fuels can be burned. The capacity of this equipment usually does not exceed 0.5–0.8 MW and the annual average efficiency does not exceed 70%. The equipment is usually relatively inexpensive; they are operated periodically and involve manual maintenance and availability of a tractor for fuel loading.

The bales of herbaceous biomass (packages) can also be used in larger boiler plants (in CHP plants) where they are pushed periodically into the furnace with the respective feeders where they burn out when moving downward along the grate or in the so-called cigar burner. The capacity of this equipment reaches 4–6 MW. Another option is where the bales are shred preliminarily and then fed into the furnace either with a screw conveyor or blown in with the forced airflow. In the latter case

either stoker boilers or fluidized bed boilers are used with the capacity that may reach tens of megawatts. The herbaceous biomass shred to a suitable size can be burned in the mix with fossil fuels or wood fuel and peat as well.

Conclusion

Based on the first laboratory tests and pilot tests the use of fuel reed (shred reed and pellets) has proved to be suitable partially. In order to gain further experience, tests should be carried out to find suitable fuel handling technologies and combustion equipment and develop combustion regimes for different types of reed. It must be considered that these fuels can be added to other biomass-based fuels, however the peculiarities of their co-combustion should be studied.



*Scientists Livia Kask and Ülo Kask making a combustion test in Vahala green house boiler room, Halikko, Finland in May 2007.
Photo: Eija Hagelberg.*



Social and economical risks of fuel reed harvesting

Further rise in price of machinery, equipment, motor fuel and labour power has also impact on the potential price of fuel reed. The producers of reed for thatched roofs and building materials may become competitors to the reed suppliers who harvest fuel for local boiler houses if the demand for these products increases. The insulated reed panels are in demand among the eco-friendly builders already today. Shredding or packing of the residues of roof reed sheaves to suit the boilers is a labour consuming and costly activity.

The competitors to the reed supply as a raw material to district heating boiler plants may also be the reed pellets and briquettes producers (production of reed pellets is planned to be started in Estonia). The demand and price of reed pellets are constantly increasing due to the price rise of liquid fuels. The market of both wood-based and herbeous biomass pellets (briquettes) in Europe is far from being satisfied and a prosperous European consumer can pay higher price than the Estonian customer evidently for several more years.

Constant outflow of high-quality labour power from Estonia may become to have serious impact on the rural regions also where there may be no workers willing to work left. This is why more effort and money must be spent on labour power recruitment or higher price paid for the reed as a raw material. So-called "pinching" of the raw material from roof reed producers would raise the price of reed as a fuel to an unacceptable level for the heat producer.


The risk factor of malicious destruction of reed beds by putting them into fire cannot also be excluded (e.g., some years at Rocca-al Mare, Tallinn).

References

- Isotalo, I., Kauppi, P., Ojanen, T., Puttonen, P. & Toivonen, H. 1981. Järviruoko energiakasvina. Tuotosarvio, tekniset mahdollisuudet ja ympäristönsuojelu. Vesihallitus, Tiedotus 210. Helsinki.
- Kask, L., Kask, Ü. & Paist, A. 2005. Energiakultuuride sobivusest energeetiliste katelde kütuseks. Konv. TEUK VI kogumik, Tartu.
- Kikas, T., Kask, Ü., & Kask, L. 2007. Saare maakonna roostike satelliidipiltide töötlemise tulemused. Keskkonnatehnika 4/07. Tallinn.
- Kütuse- ja energiamajanduse riiklik pikaajaline arengukava aastani 2015 (visiooniga 2030). 2002. Tellimustöö aruanne. TTÜ elektroenergeetika ja soojustehnika instituut. Tallinn.
- Maddison, M. 2003. Biomass ja selle kasutamine, keskkonnatehnoloogia projekt. Tartu.
- Mets, Ü. 2005. Matsalu märgala roo ja muu biomassi kasutamise võimalused energiatootmisel Lihulas. Eeluurung.
- Mäemets, H. & Freiberg, L. Characteristics of reeds on Lake Peipsi and the floristic consequences of their expansion.
- Noormets, A. 1994. Matsalu lahe lõunakalda roostike produktsoonest. Loodusvaatlusi 1993 I. Matsalu Riiklik Looduskaitseala. Tallinn.
- Paist, A., Kask, Ü. & Kask, L. 2007. Composition of reed mineral matter and its behavior at combustion. Presentation on 15th European Biomass Conference & Exhibition, ICC Berlin, 07th -11th May 2007.
- Pitkänen, T. 2006. Missä ruokoa kasvaa? Järviruokoalueiden satelliittikartoitus Eteä-Suomen ja Viron Väinämeren rannikoilla. Turun ammattikorkeakoulu, Puheenvuoroja 29. Also available in internet www.ruoko.fi/julkaisut.
- Vares, V., Kask, Ü., Muiste, P., Pihu, T. & Soosaar, S. 2005. Biokütuse kasutaja käsiraamat. Tallinna Tehnikaülikool.



Part VI



Gathering in Reed

Reed strategy in Finland and Estonia

– interdisciplinary approach

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Reed management can effect reed stands, biodiversity, landscape and water purity in many ways. Interdisciplinary project “Reed strategy in Finland and Estonia” looked for the balance between utilisation, management and preservation of reed beds and coastal meadows by compiling existing studies, carrying out own studies and making plans and strategy for pilot areas in Estonian and Finnish coastal zones during 2005-2007. The project themes were biodiversity, water protection, construction, bioenergy and landscape.

Reed has increased in number and covers up to 10% of area of some coastal municipalities in Finland. The total reed stand in Finnish Southern coastal areas was estimated with satellite images and it is approximately 30 000 hectares and in Estonia Väinameri area 20 000 hectares. (Pitkänen 2006). This material could be utilised in the future. Yearly production of reed bed is varying from 1 to 20 tons per hectare (on average 5 tons per hectare).

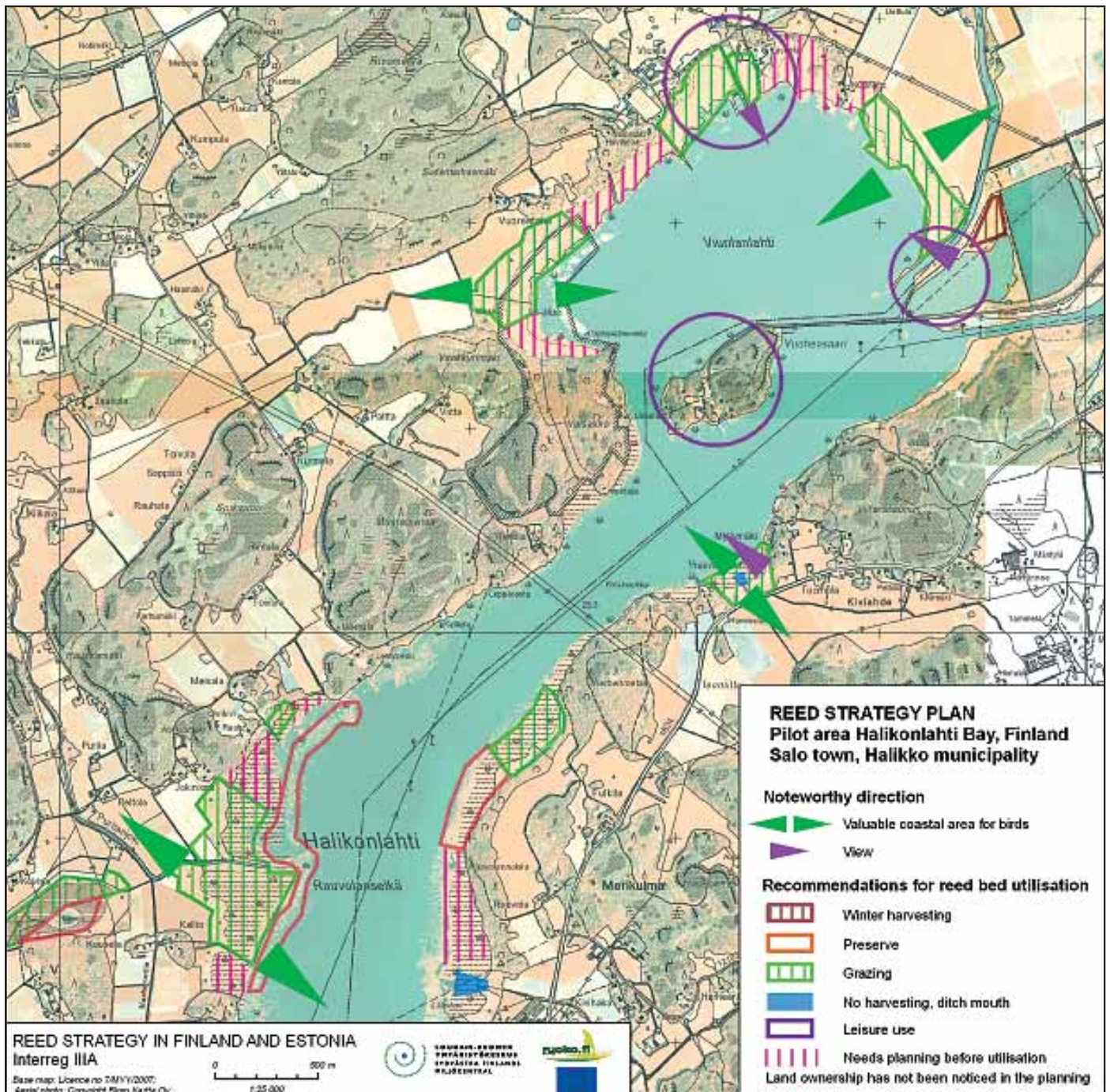
In Estonia reed has been traditionally utilised in thatching and this practice has survived. In Finland these skills are almost forgotten and reed is not harvested or utilised. In the frame of this project we contributed to bring solutions of utilisation of reed beds also to Finland. These solutions were connected with the use of reed as thatching, isolation material or local bioenergy production. Utilisation of wet reed and reed litter in summer (biogas or ethanol production) or dry reed in winter (chopped material, pellets, briquettes and bales) are interesting green solutions of future. In Estonia lot of old houses have again been repaired with traditional reed roof but also in Finland first new houses with reed roof have been built. Lihula municipality is going to use hay biomass in energy production in near future, the reed from Matsalu area would form important part from that biomass.

For creating a strategy it was important to create vegetation classification for reed beds; new kind of classification was applied for Southern Finnish circumstances during spring 2006 (Räikkönen 2007). There was a challenge to find an uniform vegetation classification approach that can be applied in different geographic locations. Reed beds vary from place to place due to the number of factors including climate, topography, soil properties and management history of the site. Differences may include e.g. bed structure, water level and presence and abundance of other vegetation. Stands of *Phragmites* vary also in height, density and thickness. These parameter served as the basis to classify the reed beds into different types that are useful information for planning, conservation and management of reed beds and coastal line.

The strategy also takes into account of wider landscape ecological views such as favourable conservation status of coastal meadows. Coastal meadows already are a minor in Finland and Estonia: several species are in the verge of local extinctions. Thus it is very important to point out areas where restoration of them should be prioritised.

The use of reed in water protection could be one important matter in future. In green zones between water bodies and fields reed can utilise nutrients effectively. Thus a large area of reed is needed especially in the mouth areas of small rivers, tributaries and ditches. This could cause important sedimentation of small particles in water and capture of nutrients before lakes or Baltic Sea. Amount of decomposing reed material will be reduced if active professional winter harvesting could be created. The importance of methane fluxes from reed beds should be calculated in the near future.

Reed project compiled and carried out wide range of studies concentrated on different project themes. Over 20 theses



The reed strategy map of Halikonlahti Bay, in the municipalities of Salo and Halikko, Finland. Map: Eija Hagelberg.

and several publications were prepared and they gave input for strategy as well. The interdisciplinary character of the project has certainly opened new perspectives to all of its participants. Thus pilot strategy is a practical tool based on compiled knowledge and latest studies about reed beds. It is meant for regional planners, municipalities, farmers and entrepreneurs and gives exact location of (1) reed beds that could be utilised, (2) reed beds that should be preserved and (3) reed beds that should be restored into coastal meadows. For national stakeholders such as Finnish Forest and Park Service it is important to find cost-effective solutions in the management of their owned coastal areas. Such solutions could include use of entrepreneurs to whom could be given min. 5-years contracts to harvest defined broad reed stands. In addition to harvesting these entrepreneurs could make relevant site-specific nature management actions with their machinery.

The approach of "Reed Strategy; www.ruoko.fi" will be hopefully adapted in coastal reed zones. Approach will enhance biodiversity, improve water quality and recreational values of coastal areas. For local stakeholders should in the future be allocated financial support for management measures of their coastal areas. New financing incentives should be included in coming EU Agri-Environment schemes (2014-) or national programmes of countries concerned. Before that it is crucial to continue finding best combined management and utilisation solutions in the frame of new projects.



Photo: Natalia Räikkönen.

References:

- Pitkänen, T. 2006. Missä ruokoa kasvaa? Järviruokoalueiden satelliittikartoitus Etelä-Suomen ja Viron Väinameren rannikoilla. Turku University of Applied Sciences publications, Puheenvuoroja vol. 29. Also available in internet www.ruoko.fi/julkaisut.
- Reed strategy in Finland and Estonia – Interreg IIIA. 2007. Southwest Finland Environment Centre. www.ruoko.fi
- Räikkönen, N. 2007. Classifying reed beds and mapping reed biomass and quality. Unpublished. Southwest Finland Environment Centre.



The joy of harvesting in the Kauklaistenjärvi -lake in 2006. Photo: Hartwig Reuter.



Come along, let's go! A Bus in Nida, Lithuania. Photo: Esko Gustafsson.

PLANTS

<i>in english</i>	<i>scientific name</i>	<i>suomeksi</i>	<i>eesti keeles</i>	<i>på svenska</i>
Bittersweet	<i>Solanum dulcamara</i>	<i>punakoiso</i>	<i>harilik maavits</i>	<i>beskkskötä</i>
Bog Arum	<i>Calla palustris</i>	<i>vehka</i>	<i>soovõhk</i>	<i>missne</i>
Calamus, Sweet-flag	<i>Acorus calamus</i>	<i>kalmojuuri</i>	<i>kalmus</i>	<i>kalmus, kalmusrot</i>
Cat's tail, Bullrush	<i>Typha latifolia</i>	<i>osmankäämi</i>	<i>laialehine hundinui</i>	<i>bredkaveldun</i>
Celery-leaved Buttercup	<i>Ranunculus sceleratus</i>	<i>konnaleinikki</i>	<i>mürktilikas</i>	<i>tiggarranunkel</i>
Common Club-rush	<i>Schoenoplectus lacustris</i>	<i>järvikaisla</i>	<i>järvkaisel</i>	<i>säv</i>
Common Duckweed	<i>Lemna minor</i>	<i>pikkulimaska</i>	<i>väike lemmel</i>	<i>andmat</i>
Common Marsh-bedstraw	<i>Galium palustre</i>	<i>rantamatara</i>	<i>soomadar</i>	<i>vattenmåra</i>
Common Reed	<i>Phragmites australis</i>	<i>järviruoko</i>	<i>pilliroog</i>	<i>vass</i>
Common Valerian	<i>Valeriana sambucifolia</i>	<i>lehtovirmajuuri</i>	<i>saleda palderjan</i>	<i>flädervänderot</i>
Cowbane	<i>Cicuta virosa</i>	<i>myrkkukeiso</i>	<i>harilik mürkputk</i>	<i>sprängört</i>
Creeping Bent	<i>Agrostis stolonifera</i>	<i>rönsyrölli</i>	<i>valge kastehein</i>	<i>krypven</i>
Cuckoo Flower	<i>Cardamine pratensis</i>	<i>luhtalitukka</i>	<i>aas-jürlill</i>	<i>ängsbräsma</i>
Cyperus Sedge	<i>Carex pseudocyperus</i>	<i>varstasara</i>	<i>kraavtarn</i>	<i>slokstarr</i>
Greater Bladderwort	<i>Utricularia vulgaris</i>	<i>isovesiherne</i>	<i>harilik vesihermes</i>	<i>vattenbläddra</i>
Greater Spearwort	<i>Ranunculus lingua</i>	<i>jokileinikki</i>	<i>suur tilikas</i>	<i>sjöranunkel</i>
Greater Tussock-sedge	<i>Carex paniculata</i>	<i>lähdesara</i>	<i>pööristarn</i>	<i>vippstarr</i>
Greater Water-parsnip	<i>Sium latifolium</i>	<i>sorsanputki</i>	<i>harilik jõgiputk</i>	<i>vattenmärke</i>
Gypsywort	<i>Lycopus europaeus</i>	<i>rantayrtti</i>	<i>harilik parkhein</i>	<i>strandklo</i>
Horse Mint	<i>Mentha longifolia</i>	<i>harmaaminttu</i>	<i>pikalehine münt</i>	<i>gråmynta</i>
Marsh Cinquefoil	<i>Potentilla palustris</i>	<i>kurjenjalka</i>	<i>soopihl</i>	<i>kråcklöver</i>
Marsh Pea	<i>Lathyrus palustris</i>	<i>rantanätkelmä</i>	<i>soo-seahernes</i>	<i>kärrvial</i>
Marsh-marigold	<i>Caltha palustris</i>	<i>rentukka</i>	<i>varsakabi</i>	<i>kabbleka</i>
Meadowsweet	<i>Filipendula ulmaria</i>	<i>mesiangervo</i>	<i>angervaks</i>	<i>älggräs</i>
Milk-parsley	<i>Peucedanum palustre</i>	<i>suoputki</i>	<i>soo-piimaputk</i>	<i>kärrsilja</i>
Purple-loosestrife	<i>Lythrum salicaria</i>	<i>rantakukka</i>	<i>harilik kukesaba</i>	<i>rantakukka</i>
Reed Canary Grass	<i>Phalaris arundinacea</i>	<i>ruokohelpi</i>	<i>päideroog</i>	<i>rörflen</i>
Reed Sweet Grass	<i>Glyceria maxima</i>	<i>isosorsimo</i>	<i>suur parthein</i>	<i>jätTEGRÖE</i>
Slender Spike-rush	<i>Eleocharis uniglumis</i>	<i>meriluikka</i>	<i>soomusalss</i>	<i>agnsäv</i>
Spike-rush	<i>Eleocharis sp.</i>	<i>luikka</i>	<i>alss</i>	<i>sävar</i>
Tufted Hair-grass	<i>Deschampsia cespitosa</i>	<i>nurmilauha</i>	<i>luht-kastevars</i>	<i>tuvtätel</i>
Tufted Loosestrife	<i>Lysimachia thyrsoflora</i>	<i>tertualpi</i>	<i>ussilill</i>	<i>topplösa</i>
Valerian	<i>Valeriana officinalis</i>	<i>rohtovirmajuuri</i>	<i>harilik palderjan</i>	<i>läkevänderot</i>
Water Horsetail	<i>Equisetum fluviatile</i>	<i>järvikorte</i>	<i>konnaosi</i>	<i>sjöfräken</i>
Water-plantain	<i>Alisma plantago-aquatica</i>	<i>ratamosarpio</i>	<i>harilik konnarohi</i>	<i>svalting</i>
Wild Angelica	<i>Angelica sylvestris</i>	<i>karhunputki</i>	<i>heinputk</i>	<i>stätta</i>
Willow	<i>Salix sp.</i>	<i>paju</i>	<i>paju</i>	<i>vide</i>
Yellow Loosestrife	<i>Lysimachia vulgaris</i>	<i>ranta-alpi</i>	<i>harilik metsvits</i>	<i>strandlysing</i>
Yellow Water-lily	<i>Nuphar lutea</i>	<i>isoulpukka</i>	<i>kollane vesikupp</i>	<i>gul näckros</i>



Finnish native cattle on shore. Photo: Eija Hagelberg.

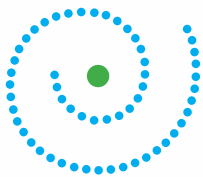


BIRDS

in english	scientific name	suomeksi	eesti keeles	på svenska
Arctic Tern	<i>Sterna paradisaea</i>	lapintiira	randtiir	silvertärna
Bar-tailed Godwit	<i>Limosa lapponica</i>	punakuiri	vöötsaba-vigle	myrspov
Bearded Tit (Bearded Reedling)	<i>Panurus biarmicus</i>	viiksitimali	roohabekas	skäggmäs
Bewick's Swan	<i>Cygnus columbianus</i>	pikkujoutsen	väikeluik	mindre sångsvan
Bittern	<i>Botaurus stellaris</i>	kaulushaikara	hüüp	rördrom
Black Tern	<i>Chlidonias niger</i>	mustatiira	mustviires	svarttämä
Black Coot	<i>Fulica atra</i>	nokikana	lauk	sothönä
Black-headed Gull	<i>Larus ridibundus</i>	naurulokki	naerukajakas	skrattmås
Black-tailed Godwit	<i>Limosa limosa</i>	mustapyrstökuiri	mustsaba-vigle	rödspov
Blue Tit	<i>Parus caeruleus</i>	sinitiainen	sinitihane	blåmes
Bluethroat	<i>Luscinia svecica</i>	sinirinta	sinirind	blåhake
Broad-billed Sandpiper	<i>Limicola falcinellus</i>	jänkäsirriäinen	plütt	myrsnäppa
Caspian Tern	<i>Sterna caspia</i>	räyskä	räusk	skräntärna
Citrine Wagtail	<i>Motacilla citreola</i>	sitruunavästäräkki	kuldhänilane	citronärla
Common Redshank	<i>Tringa totanus</i>	punajalkaviklo	punajalg-tilder	rödbena
Common Tern	<i>Sterna hirundo</i>	kalatiira	jögitiir	kisktärna
Corncrake	<i>Crex crex</i>	ruisrääkkä	rukkirääk	kornknarr
Crane	<i>Grus grus</i>	kurki	sookurg	trana
Gadwall	<i>Anas strepera</i>	harmaasorsa	rääkspart	snatterand
Great Crested Grebe	<i>Podiceps cristatus</i>	silkkiuikku	tuttpütt	skäggdopping
Great Grey Shrike	<i>Lanius excubitor</i>	isolepinkäinen	hallögija	varfågel
Great Reed Warbler	<i>Acrocephalus arundinaceus</i>	rastaskerttunen	rästas-roolind	trastsångare
Grey Heron	<i>Ardea cinerea</i>	harmaahaikara	hallhaigur	häger
Hen Harrier	<i>Circus cyaneus</i>	sinisuohaukka	välja-loorkull	blå kärrhök
Knot	<i>Calidris canutus</i>	isosirri	suurrüdi	kustsnäppa
Lapwing	<i>Vanellus vanellus</i>	töyhtöhyypä	kiivitaja	tofsvipa
Lesser Spotted Woodpecker	<i>Dendrocopos minor</i>	pikkutikka	väike-kirjurähn	mindre hackspett
Little Crake	<i>Porzana parva</i>	pikkuhuitti	väikehuik	minde sumphöna
Little Grebe	<i>Tachybaptus ruficollis</i>	pikku-uikku	väikepütt	smädopping
Little Gull	<i>Larus minutus</i>	pikkulokki	väikekajakas	dvärgmas
Marsh Harrier	<i>Circus aeruginosus</i>	ruskosuohaukka	roo-loorkull	brun kärrhök
Marsh Sandpiper	<i>Tringa stagnatilis</i>	lampiviklo	lammitilder	dammsnäppa



<i>in english</i>	<i>scientific name</i>	<i>suomeksi</i>	<i>eesti keeles</i>	<i>på svenska</i>
Meadow Pipit	Anthus pratensis	niittykirvinen	sookiur	ängsbiplärka
Merlin	Falco columbarius	ampuhaukka	väikepistrik	stenfalk
Montagus's Harrier	Circus pygargus	niittysuohaukka	soo-loorkull	ängshök
Moorhen	Gallinula chloropus	liejukana	taim	rörhöna
Mute Swan	Cygnus olor	kyhmyjoutsen	kühmnokk-luik	knölsvan
Northern Hobby	Falco subbuteo	nuolihaukka	lööpistrik	lärkfalk
Osprey	Pandion haliaetus	kalasääski	kalakotkas	fiskgjuse
Pochard	Aythya ferina	punasotka	punapea-vart	brunand
Red-necked Phalarope	Phalaropus lobatus	vesipääsky	veetallaja	smalnäbbad simsnäppa
Redpoll	Acanthis flammea	urpiainen	urvalind	gråsiska
Reed Bunting	Emberiza schoeniclus	pajusirkku	rootsiitsitaja	sävspurv
Reed Warbler	Acrocephalus scirpaceus	rytikerttunen	tiigi-roolind	rörsångare
Ruff	Philomachus pugnax	suokukko	tutkas	brushane
Savi's Warbler	Locustella luscinioides	ruokosirkkalintu	roo-ritsiklind	vassångare
Sedge Warbler	Acrocephalus schoenobaenus	ruokokerttunen	körkja-roolind	sävsångare
Slavonian Grebe	Podiceps auritus	mustakurkku-uikku	sarvikpütt	svarthakedopping
Smew	Mergus albellus	uivelo	väikekoskel	salskrake
Snipe	Gallinago gallinago	taivaanvuohi	tikutaja	enkelbeckasin
Sparrow hawk	Accipiter nisus	varpushaukka	raudkull	sparvhök
Spotted Crane	Porzana porzana	luhtahuitti	täpikhuik	småfläcklig sumphöna
Starling	Sturnus vulgaris	kottarainen	kuldnohk	stare
Swift	Apus apus	tervapääsky	piiritaja	tornseglare
Tufted Duck	Aythya fuligula	tukkasotka	tuttvart	vigg
Water Rail	Rallus aquaticus	luhtakana	rooruik	vattenrall
Whooper Swan	Cygnus cygnus	laulujoutsen	laululuik	sångsvan
Willow Warbler	Phylloscopus trochilus	pajulintu	salu-lehelind	lövsångare
Wood Sandpiper	Tringa glareola	liro	mudatilder	grönbena
Wren	Troglodytes troglodytes	peukaloinen	käblik	gärdsmyg
Yellow Wagtail	Motacilla flava	keltavästäräkki	hänilane	gulärla
Other animal species				
Aquatic sowbug	Asellus aquaticus	vesisiira	vesikakand	vattengråsuggan
Large White-faced Darter	Leucorrhinia pectoralis	täplälampikorento	suur rabakiil	citronfläckad kärrtrollslända
Mealy Plum Aphid	Hyalopterus prunii	luumukirva		plommonbladlus
Mummichog	Fundulus heteroclitus	siniraitahammaskarppi		
Twin-spotted Wainscot	Archanara geminipuncta	pilkkuuokoyökkönen		tvillingfläskat rörfly



Opinions on reed beds vary. In the coastal areas of Finland and Estonia, reed beds are occasionally viewed as a threat to leisure use, water protection and the life forms of coastal meadows. On the other hand, reed beds can bind solid matter in catchment water and offer protection for man and various animal species. Reed beds conceal surprising possibilities for their use. This book looks at reed from many different angles.