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# INTEGRATED COASTAL ZONE PLANNING AND MANAGEMENT IN THE BALTIC REGION

## A GIS-model developed in Gotland

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# Preface

This publication is a product of the Natureship project (2009–2013), co-ordinated by the Centre for Economic Development, Transport and the Environment in the Southwest of Finland. Natureship is an international project with partners in Estonia, Finland and Sweden. The project is financed by the Central Baltic Interreg IV A Programme together with national financiers. Natureship has a total of eleven partners: The Centre for Economic Development, Transport and the Environment in the Southwest of Finland, the University of Turku Department of Geography and Geology, Metsähallitus, Luontopalvelut (Natural Heritage Services) in the cities of Hamina, Raisio and Salo, and the municipality of Vihti, Norrtälje Nature Conservation Foundation, the County Administrative Board of Gotland, Estonian Environmental Board and the University of Tartu.

The objective of the project is to promote co-operation within nature conservation and water protection in Finland, Sweden and Estonia. Within the project, coastal planning, is implemented in accordance with sustainable development and, together with other parties, the project attempts to find cost-effective solutions which benefit water protection and biodiversity. The Estonian, Finnish and Swedish project partners are testing different planning methods for coastal areas by combining geographic information system (GIS) material with historical material, by testing innovative maintenance methods and proposing recommendations, as well as by examining key species of culture biotopes. Furthermore, the project evaluates ecosystem services, i.e., the tangible and intangible benefits humans receive from nature.

The principal products of the project are six publications concerning nature conservation. Electronic versions of all of the publications can be downloaded at the project website www.ymparisto.fi/natureship.

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Project co-ordinators for the Natureship project

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# 1 Summary

The coastal zones are of great value, not just in terms of nature and culture but also with regards to recreation. It is therefore important that their current management is carried out in a sustainable manner, so that future generations can also utilize and enjoy them. To succeed in this, knowledge and efficient public planning are crucial.

The objective of the project *Integrated coastal zone planning and management in the Baltic region* will facilitate physical planning in the coastal zone as well as constituting a useful basis for establishing new forms of management. The long-term idea is that the developed GIS model shall be used by the public, in order to obtain information about recreation, exploitation and conservation values.

The project is one of eleven partners in a cross-border project called Natureship and has been conducted within the framework of the EU's Central Baltic Interreg IV A Programme. In addition to Sweden, Finland and Estonia are also participating in the main project Natureship that focuses on sustainable planned and managed coastal areas and networks of key areas and habitats.

Based on the existing maps, a GIS model has been produced that illustrates the conservation values and exploitation interests and where they collide. Gotland and its 770 kilometres of coast has served as a trial area but the established GIS model can be applied to any region. The conservation values have been divided into classes depending on their assessed value. In this way, the results indicate the parts of the coastal zone which are of greatest value. Exploitation interests have not been classified in the same way as there is insufficient knowledge of them. Together with the identification of ecosystem services and social values in the landscape, this is a future opportunity for development. Furthermore, the results from the model need to be compared with real data, in order for the material to be useable.

There is much work to be done before the model can become a comprehensive tool for physical planning in the coastal zone. But the results of the project are an important step along the way. The GIS model forms a stable basis and is flexible enough to include the areas and materials which will be requested as the project proceeds. It can therefore be considered a good foundation on which to build.

# 2 Introduction

Since the beginning of time, and all over the world, people have always been attracted to living in coastal regions. The coasts are the focus for a great number of interests and in order to secure their natural resources and the ecosystem services which the areas provide us with, we must learn to utilize them in a sustainable manner. This requires knowledge and efficient tools. One such tool is public planning and surveys based on GIS data, which the project *Integrated coastal zone planning and management in the Baltic region* has studied in more detail.

In the proposition 2008/09:214, concerning ocean policy, the Swedish Government described the ocean as an indispensable resource. It states that a comprehensive view of the ocean usage is necessary for a sustainable development. The establishment of the new Swedish Agency for Marine and Water Management (SwAM) is one part of the process to create a comprehensive incentive for marine environmental issues in the country. An investigation into the improvement of planning within Swedish territorial waters has also been carried out and the investigation submitted its main report in December 2010 *Planering på djupet – fysisk planering av havet (In-depth planning – physical planning for the ocean)* (SOU 2010:91). In January 2011, the Government decided on an amendment directive to the investigation, dir. 2011:3, which meant that the scope of the investigation was expanded and extended. The expansion concerned the need for the coherent provision of knowledge, with regards to efficient ocean planning.

## 2.1 Gotland, the magical island

Situated in the middle of the Baltic is the Swedish island Gotland. Its 770 kilometres of coastline make it Sweden's largest island. The Hanseatic city of Visby has been designated as a UNESCO World Heritage site and the island as a whole possesses unique natural and cultural values. The fact is that these values are so highly rated that they constitute sufficient grounds for the designation of the entire island as an ancient monument or a Natura 2000 site. However, this cannot be done as it would have enormous consequences for the survival of the region but nevertheless, it is important to bear this in mind when public administration and planning on Gotland are discussed.

Gotland's countryside appears like it does today as a result of the way it has been utilized for thousands of years, from the Stone Age to today. The coasts were the part of the island that were first utilized, approximately 8,000-10,000 years ago. The rocks are sedimentary and stem from the Silurian period, approximately 400 million years ago. Different geological strata with different properties run in southwest-northeast bands and this can be seen in the diagonal tracts of arable and forest land which characterize the area.[1]

Historically, the settlements on Gotland have primarily been established some distance inland, for several reasons. Large sections of coast have traditionally been owned by communities and not by private individuals. The farms have utilized the coast communally for seaweed harvesting and fishing, which has meant that the land has not been built on. Furthermore, Gotland's location, in the middle of the Baltic Sea and Sweden's eastern outpost, has been of great value to the Swedish military. Large areas of the island have for long periods been owned by the military land and have for that reason not been developed. As the military's needs and interests have changed, land that has previously been closed to the public has become accessible. Changes like these also pose increased demands on planning and management so that development in the coastal areas can continue in a sustainable manner.

*Image 1. Overview of the model areas in Sweden, Finland and Estonia. The County Administrative Board of Gotland © Lantmäteriet - the Swedish mapping, cadastral and land registration authority.*

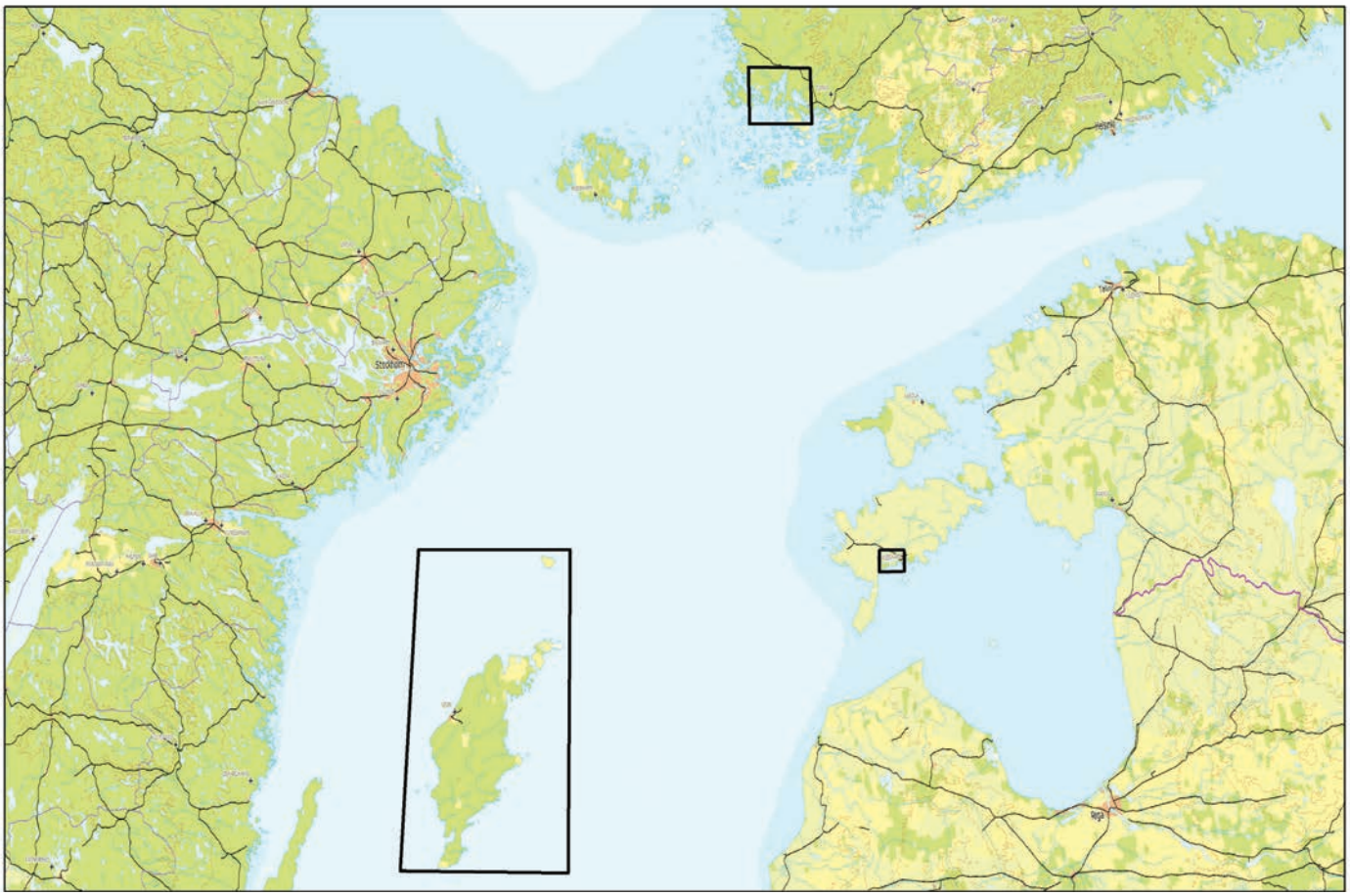


*Image 2. Tomtbods fishing village. Photo: Magdalena Lindholm*

## 2.2 Natureship

The work conducted on Gotland is part of a cross-border project within the EU's Central Baltic Interreg IV A Programme. The cross-border project, called Natureship, has 11 participating partners including Gotland, which represents Sweden, Finland and Estonia. The Natureship project focuses on sustainable planned and managed coastal areas and networks of key areas and habitats. The goal is to improve the conditions in the Baltic by developing methods for coastal zone planning and particularly for the management of coastal areas. The principal product of the project is a "Habitat Management Library" that will consist of six publications. Within the framework of the Natureship project, innovative trials and exchanges of information are conducted between the work groups. Tested results and the experience drawn from these will be presented in the publications.

The Gotland subproject has been ongoing since 2009 and will be concluded during 2012. During the project period, there has been a work group at the County Administrative Board of Gotland as well as a steering group consisting of managers from the same authority. Furthermore, there has also been an external reference group with representatives from Region Gotland, Lantmäteriet - the Swedish mapping, cadastral and land registration authority, Gotland's Museum and Gotland University.

## 2.3 Purpose, objective and target group

The purpose of the project is, via existing GIS information, to develop a quantitative method for the classification of different types of conservation values and thereby find out where the greatest biological and culture historical values are located and therefore where there is an abundance of ecosystem services. Furthermore, these are compared to exploitation interests in the coastal zone.

The objective of the project is to facilitate and find a new tool for social planning in the coastal zone by highlighting values for recreation, exploitation and conservation within the coastal zone area. The main focus is primarily the coastal zone of Gotland, but there are also two areas in Finland and Estonia included in the study. The GIS model which has been produced will assist physical planning in the coastal zone and, in the long term, be a source of knowledge for recreation and outdoor life.

The project is primarily aimed at authorities and municipalities that request tools for physical planning in the coastal zone. The results also lend themselves to different types of co-operation in the coastal zone as well as forming a basis for the development of new forms of management.

# 3 Public administration and ecosystem services

Physical planning and public administration are two important components in the work to preserve and maintain the ecosystem services which nature provides for mankind. Acknowledgement of the role of nature and scope for planning are paramount, for sustainable usage of natural resources.

## 3.1 The County Administrative Council

As a link between, on one hand, the general public and the municipalities and, on the other hand, the Government, Riksdag (the Swedish Parliament) and national authorities, the County Administrative Councils of Sweden have a unique role within democratic society. Sweden is divided into 21 counties[2] and each county has its own County Administrative Board and County Governor. The County Administrative Councils are national authorities with responsibility for supervision, community services and they can also function, in applicable cases, as appeal courts.

The County Administrative Board has the task of working with conservation issues such as protection of valuable areas and species and at the same time acts for the benefit of the public so that everyone can benefit from and have access to nature. In other words, it is the County Administrative Council's job to not only preserve the natural landscape, natural resources and biodiversity, but also to ensure that it is developed and enjoyed in a sustainable manner.

The ambition of Gotland County Administrative Board is that financial, social and environmental consequences shall be considered in all decisions made by the authority. In order to live up to this, access to a comprehensive, multi-sectoral knowledge base is required. The project is seen as an important stage in this process.

## 3.2 Dialogue as a tool in public administration

In order to achieve successful public physical planning and administration in areas where there are many opposing interests, open dialogue is very important. Through dialogue, interests and values can be weighed against each other and constructive solutions can be applied to any potential disagreements. This places demands on cross-sectional work within the authority but also requires a firm foundation and collaboration with parties affected by the area in question, such as land owners, business owners, residents and non-profit organizations.

An open decision process and dialogue around the considerations made often contribute to increased trust of the authorities involved and a better understanding in the parties concerned. A firm foundation also makes for more stable decisions as local knowledge is combined with the expert knowledge of the authorities. Dialogue and collaboration increase the opportunities for good physical planning which strives for sustainable development and an administration which welcomes both conservation and development.[3]

## 3.3 Geographic Information System – a planning tool

GIS stands for *Geographic Information System* and it is used to collect, store, analyze and present spatial data. Within the public sector, geographic information systems are important tools for making well-balanced decisions. GIS helps to make analysis and presentation faster and more efficient than manual methods that have been used traditionally. Existing data can, via GIS, be much more easily used to process the basis for decisions within most activities.

## 3.4 Ecosystem services

The ecosystems that are found in nature can be described as composite units where there is a functioning interplay between animals, plants and the physical environment, e.g. a lake or a forest. These systems offer an abundance of usefulness in the form of natural resources and processes that are necessary for our survival. This usefulness is known as ecosystem services and consists

of e.g. foodstuffs, bioenergy, water purification and the ability to mitigate the consequences of natural disasters.[4] The coastal zones produce a great number of ecosystem services which mankind can utilize, which is a major contributory factor to why these areas are so attractive for habitation and exploitation.

Ecosystem services can be divided into four categories; provisioning services, regulating services, supporting services and cultural services. The *Provisioning Services* category consists of natural resources such as nutrition, clean drinking water, the air we breathe, fuel and building materials. *Regulating and supporting services* are more difficult to define. They include pollination of crops and plants, nutrient cycles and the preservation of the natural environment. The last category, *cultural services*, includes the possibility of outdoor activities, recreation and the aesthetic values of nature.[5]

In many cases, ecosystem services are dependent upon the preservation of biodiversity. This can be achieved through, for example, the preservation of nutrition cycles and pollination. The European ecosystems of today often have a broad spectrum of services to offer, which reduces vulnerability. One possible effort within an individual service in a specific area can affect the capacity to deliver other equally important ecosystem services. This is something that should be avoided wherever possible and it is therefore important that the directives for this are jointly developed and implemented.[6]

Ecosystem services are, even if they are often unevenly distributed, free and accessible to all. The services are often taken for granted and are therefore not valued in financial terms. Ecosystem services are very vulnerable, not infinite and dependent on mankind for their existence.[7] In other words, they have a clear value, yet they are rarely seen on balance sheets or when companies or the general public discuss the environment.[8] This is due to the great difficulty in measuring the financial value of ecosystem services. The lack of an actual figure for the value of the services is often a disadvantage when it comes to negotiations regarding environmental benefits and environmental damage. The establishment of a market value would give the services an importance connection with commercial and social investments.[9]

In order to create a sustainable society, ecosystem services must play a clear role in the official decision-making process. Despite this, the understanding of the concept is often poor and its practical application in official decisions is limited. The value of the ecosystem services is often overlooked in decision-making, something that in the long term may result in significant losses for both nature and mankind.[10]

Global food supply is one of the greatest challenges of our time and one where ecosystem services are of crucial importance. In order to meet increasing demand, the production of foodstuffs needs to increase by 50 per cent over the next 40 years. At the same time, the amount of crop harvests being used for biofuels is increasing. Intensive monoculture, regardless of whether it is for bioenergy or foodstuffs, leads to the ecosystems becoming adapted to a single service which in the long term means that the other services, e.g., climate regulation are postponed. Monoculture can therefore lead to losses of e.g., clean water, fertile land etc.[11]

Decision-makers and other governing bodies in society are constantly confronted with questions regarding costs to society and revenue derived from, action programmes, threats to and development of the coastal zone and its ecosystem. It is therefore very important that they receive better and more detailed knowledge regarding ecosystem services.[12]

## 3.5 Read more about ecosystem services

*Millennium Ecosystem Assessment,* MA, is a global study conducted by the UN. The purpose of the study is to evaluate and collect knowledge about the condition of the ecosystems and of the ways in which mankind is dependent on them for its survival and development.[13] When MA was concluded in 2005, one of the conclusions was that 60 per cent of the 24 assessed ecosystem services are in the process of being depleted. Resilience is an ecosystem's long term ability to survive and continue developing after heavy impact, e.g., by climate changes. There is a strong connection between biodiversity and an ecosystem's resilience and ability to deliver services.[14]

The study describes the conditions of the world's ecosystems with a focus on ecosystem services and their importance for society and the economy. The results show that certain ecosystem services e.g., the production of crops and wood, have increased over the last 50 years. This increase however, has happened at the expense of other ecosystem services such as access to drinking water and fish catches but primarily, the ecosystems have been eroded to such an extent that their long term capacity to deliver ecosystem services and their ability to withstand disturbances have been reduced. One of the most important conclusions in the study is that a careful

usage of natural resources not only leads to a retained ability for the ecosystems to withstand changes, but it is also socio-economically viable.[15]

*The Ecosystem Approach* can be described as a working method for the conservation and sustainable use of land, water and living resources. The approach seeks a balance between the conservation and use of biodiversity and the equitable distribution of the benefits of genetic resources. The ecosystem approach highlights the importance of the ecosystems as a function which produces goods and services, the ecosystem services upon which mankind depends. Furthermore, it should also be pointed out that both public and private measures should be based on scientific methods focussing on structures, processes, functions and interaction between organisms and their environment.[16]

The ecosystem approach is divided into twelve principles. These can be summarized in three areas; integration, adaptivity and participation:

• ***Integration:*** The current environmental issues require, to an increasing extent, collaboration over borders between water and land, collaboration over scientific borders as well as between science and general knowledge, collaboration over levels of administration and sectors, between the private and the public, between different types of usage etc.

• ***Adaptivity:*** We do not have complete knowledge about how nature works or how society responds or develops. The result is that the measures and efforts we make do not always have the expected or desired effect and the administration must then be able to be adjusted. Adaptive administration is recommended when knowledge is lacking, when there are many interests to be balanced against each other and when there are external uncertainties or changing elements within nature or society. Three factors that are often valid with regards to the administration of coastal areas are:

• ***Participation:*** Participation from concerned parties is crucial. Participation is a democratic right and the supply of resources should be divided equally. The users of the area have valuable knowledge. It is easier to implement decisions if the concerned parties have participated in the process.

*The Economics of Ecosystems and Biodiversity,* TEEB*, -* the report aims to increase understanding of the value of biodiversity in both monetary and non-monetary terms. It shall be achieved through an increase in knowledge of the benefits of biodiversity and ecosystem services but also by reporting the consequences, should they be reduced or disappear completely.[17]

*The European Academies Science Advisory Council,* EASAC*,* published a policy report in 2009 in which the connection between biodiversity and ecosystem services was investigated. The report concluded that it makes sense to look at ecosystem services from a European perspective. It also suggests possible policies and systems for the maintenance and conservation of the ecosystem services that exist in Europe.[18]

*The Natural Capital Project* revolves around the development of alternative administration methods to enable a deeper understanding of the ecosystem's services and products. This is brought about by developing methods for calculation and reporting of the total value of the services. The results will hopefully function as a basis for policy and administration decisions.[19]

*Image 3. Helgumannen's fishing village, Fårö. Photo: Magdalena Lindholm*

# 4 The cultural heritage of the coast

Gotland, with its location in the middle of the Baltic Sea, has always been an object of interest, for various different reasons. From the hunting grounds and settlements of the first humans, via the power struggles of the Middle Ages, to the attractive tourist paradise of today, the island has constantly been reshaped and developed.

## 4.1 The history of Gotland – a summary

Habitation on Gotland is concentrated around the inland, more fertile areas of the island. Usage of the coast has long been a communal asset. In the city law of Visby from the 1340s, the coast of Gotland is established by law as a free zone for everyone.[20] The majority of the coast has belonged to private land owners but much has also belonged to the community. All farms should have access for the berthing of boats, fishing, hunting and the seaweed harvest. From the 19th century, a fishing village could pay leasehold to the land owner in the form of herring.

Water and access to food were the prerequisites behind the first acquisitions of land on the island. Farms gradually appeared, maybe due to the growth of the population. Seafaring and trade developed but religious interests also served as an engine of growth in the formation of the kingdom, financial associations and other positions of power.

Currently there are approximately 1,500 farms on Gotland that receive EU subsidies.[21] There are approximately 1,800 known Iron Age building foundations. Added to this are a number which are unknown, have become overgrown, or which for other reasons have not been preserved. Research today suggests that the fenced in land has been fairly constant since at least the Iron Age, but also that the farms have a long history – from the building foundations of the Iron Age to the settlements from the Viking Age, currently situated in arable land, the medieval settlements as well as the farm locations which can be found in the geometric map from the end of the 17th century. The settlements have only been moved within the near vicinity. The farms' location on the geometric map matches their current location, to a high degree. During certain periods, there is very little proof of settlements having existed, due to the use of organic material.

A recently conducted study has shown that the number of farms put *"in rudera"*, laid to waste from the Viking Age/Middle Ages and up until the time of the geometric map amounts to approximately 800.[22] The cause of the great decline has been stated as being the Black Death, King Valdemar IV of Denmark's annexation of the island, climate degradation, etc. In the 17th century, the public was not permitted to build wooden houses as the Crown needed the timber to build warships and people instead had to construct their buildings using stone. The Gotland countryside has probably not changed much until recent times. The moving of the farms in the nearby area has probably not affected the landscape as a whole and the road network has a very old-fashioned structure.

Over the last three hundred years, several laws were implemented, whereby settlements were dispersed and land redistributed into one or more pieces per farm, in order to restructure the landscape into areas which were more interconnected. Traditional division of the farm's acreage had meant that the farm's fields could be spread out over a large area.[23]

The marshes were much more extensive than those we can see today. This is the result of the ditching which has taken place over the last two hundred years. The total size of the arable land today is approximately 85,000 hectares and, out of this, approximately 30,000 hectare is old marshland.[24] One example of this is the discovery of a dugout canoe in 2002. It had become stuck on a carrot harvester and the place where it was found was once the marsh known as Martebomyr.[25] The flat bottom of the dugout canoe was excellent for movement across the marsh. It could later be dated back to the Bronze Age. The extensive spread of the marshland is also visible in old place names that allude to water, e.g., the farm Myrände in Atlingbo. Many words and names with connections to water or seafaring are words borrowed from e.g., Finnish and Estonian.[26]

When kingdoms are formed during the early Middle Ages, Gotland is an object of interest for several different parties. The Hanseatic League developed in the Baltic region, the Danish King Valdemar IV landed and invaded the island in 1361. In the 16th century, the Nordic Seven Years' War was fought off the coast of Gotland and during a storm in 1566, approximately 5,000 men and 15 ships were lost in the waters outside of Visby harbour.[27]

Gotland came under Swedish rule at the Second Treaty of Brömsebro in 1645. This was when the geometric map was made, in order to establish the number of farms and how much tax the Crown could collect from the island. But less than 200 years later, the island is annexed, this time by the Russians. In 1808, Rear Admiral Bodisco set foot on the island and for 22 days Gotland is Russian but the Rear Admiral surrendered fairly promptly when the Swedish fleet arrived.

Gotland's vulnerable location in the Baltic Sea meant that defence was a necessity. The purpose of the hill forts from the Bronze Age and onwards is debated but it is likely that, for a period of time, some of them were used as fortification. There are also relics from the 17th and 18th Centuries in the form of redoubts and Karlsvärd's fortress at Enholmen is starting to develop.

During World War I, damage was inflicted on a German minelaying cruiser, SMS Albatross by Russian cruisers off the eastern coast of Gotland. The Albatross was forced to run aground and the crew were interned on the island. After this event, a permanent fleet was installed on Gotland in order to prevent similar occurrences.[28] The military presence on Gotland has a long history and during the two World Wars, a number of facilities of various kinds are established on the island. Several of these have already been decommissioned and now it is the turn of the facilities along the coast as they no longer fulfil any function.

At the end of World War II, Baltic soldiers and German soldiers from the Baltic states fled to Gotland. The Swedish Government decided that all military refugees would be extradited, most of them to the Soviet Union. For many, this meant an uncertain future in the Soviet Gulags. Some escape boats can still be found around the island.

Image 4. Karlsvärd's fortress at Enholmen. Photo: Tor Sundberg


*Image 5. Escape boat from Gotska Sandön. Photo: Majvor Östergren*

## 4.2 Cultural remains in the coastal zone

From a historical perspective, the coastal zone should have an abundance of cultural remains of various kinds. The rich history of Gotland, briefly described above, should in many ways be reflected through its landscape. But unfortunately, our knowledge of the coastal remains is still limited. Isostatic uplift changes the conditions for being able to determine positions and places move as the coastal line changes. changes the conditions for being able to determine positions and places move as the coastal line changes. New reefs and straits are formed, which makes it difficult to interpret the old coastal landscape. However, the traces are there for us to discover. Within the part of the coastal zone included in this study, almost 5,000 remains are registered in the Archaeological Sites and Monuments database (FMIS). Some of them are presented below.

The coast has in many ways been prerequisite for Gotland's history. When the first humans arrived, the hunting of seals and seabirds was the foundation for their existence, along with fishing. The caves found along the coast were often used for these activities. This much is known due to the finds at Stora Karlsö and the large quantity of cultural material discovered in the Stora Förvar cave.

From the very beginning, the importing of goods has been of great significance. The flint from Gotland could not be compared with that from southern Scandinavia, which was imported as early as during the Stone Age. The island may also have functioned as a transit centre for fur, raw bronze, amber, weapons etc. during the Bronze Age. Gotland has a wealth of objects that has no counterpart elsewhere in Sweden. The plethora of Iron Age objects on Gotland indicates plentiful contacts with the outside world, either as raw material for processing by craftsmen on Gotland, or as ready-made imported products. It is primarily metals which would have come to the island via the ports but it is probable that large amounts of glass, fabrics and spices also arrived in this manner. A bronze face mask from the late 2nd century was found in the northern part of the island. It is characterized by Roman iconography, unique to Sweden and Gotland. The mask has, together with several other objects, been hidden in a building that was abandoned during the 7th century. Several of the objects are imported, from both the east and the west.

Perhaps the ”storrösen”, great mounds located along the coast are evidence of intensified contacts with the outside world. Whatever the reason, it was important for the inhabitants to manifest their presence through the great mounds located along the coastline, which were especially visible from the sea. The somewhat younger stone ships are today interpreted as a clear pointer to the importance of the sea.

Across the Baltic, especially the settlements in Grobin (Latvia) and Truso (Poland) bear witness to the contact with Gotland. Extensive burial grounds indicate that Gotlanders in all probability lived and worked there, and that they definitely died there. As a connecting link, the only Gotlandic picture stone outside of Sweden was found at the burial ground in Grobin. The picture stones are also in many cases expressions of the importance of the coast, sea and seafaring. The Vikings used only a few different types of images to depict their lives and a large proportion of these images include boats and ships.[29]

Two ships from the Viking period were found in connection with ground works on the island of Saaremaa a few years ago. Inside the ships were approximately 35 souls who died approximately 1,200 years ago. The ships also contained various equipment, including fragments of swords.[30]

Recent studies of Viking harbours have shown that there should be more harbours and fishing villages than those of which we are currently aware, and also that there should be many different types, from the smaller fishing villages, which provided for the farms, up to the larger, more or less permanent settlements with their small shops, ship building industry etc. Considering the extensive trade during this period, it can be assumed that the situation is the same for the rest of the Baltic region.[31]

Place names stemming from the Viking Age speak of coastal activities, especially names containing ”snäck” which is the old name for the boats typical of the Viking Age ”snäckan”. With cultural geographical studies, archives and map studies, phosphate surveys and sample pits, the location of earlier ports can be established.[32] The Viking fishing villages and those used for trade and other harbour activities can be seen in the landscape through the existence of stone sleepers and the remains from fireplaces found at fish stalls and trade stalls, through the post holes made by drying stands for fishing nets and other findings such as balance scales, lead weights, fishing tools, etc. The harbours at Nymans in Fröjel and Bogeviken in eastern Gotland are considered to be two of the island’s most important harbours and trading places from the Viking Age. The large amount of silver treasure found at Spillings near Bogeviken should be viewed as the result of contacts made to the east of the area which is today known as Slite. The Spillings treasure is the world’s largest silver treasure and weighed 67 kg. In addition to this, there is a bronze deposit, which weighs just under 20 kg.

There was extensive processing of metals on Gotland and remains from blacksmiths have been found throughout the island. Visby has been described as one of the most important places in the Baltic region for trade in iron. Along Smedjegatan, immense deposits of iron slag and pieces of iron from the north of Sweden, ”osmundar” have been found. Several of the silver treasures found in Finland have shown that they originated on Gotland.[33]

A rune stone from the Stockholm area, from the 11th century, tells the story of how the parents of Vinaman erect a stone to commemorate their son who, for an unknown reason, died when he visited Boge. Apparently, Boge was a concept so well known in Uppland that it could be mentioned without needing to add that it was actually a location in Gotland.[34]

*Image 6. Bläse lime kilns and fishing village. Photo: Tor Sundberg*

*Image 7. Fishing village at Holmhällar. Photo: Ilse Hammarström*

The harbours and trading places of the Viking Age lost their importance, perhaps due to the establishment of merchants as a social class and the dawning of Visby's golden age. The medieval harbours were probably, to a much greater extent than previously, organized in administrative systems, in the same way as the rest of society.[35] During the Middle Ages, a bulwark was erected in the Tingstäde swamp, which may have had several purposes - trading place, defence position, etc. Due to increased contacts and an increased level of trade during the Viking Age and early Middle Ages, large stone warehouses (storage buildings) started to be built.

At this time, stone churches are also built, as well as some non-secular buildings. The need for stone material could be met by domestic production but craftsmanship and engineers came from the continent. The export of limestone fonts is important during the Middle Ages. In several of Gotland's churches, ships are carved into the plasterwork. One theory is that they are offerings from the poor in return answered prayers, as opposed to the more detailed ships. The votive offerings were a clear reminder of the victims of the sea. In various places, there are even special burial grounds for seamen who died of cholera; however, this was primarily due to the risk of infection.

The entire north of Gotland is characterized by the history of the limestone industry. The limestone industry has over the years been of great importance, and it still is today. The quarrying of limestone and sandstone required special shipping harbours. The places used for limestone processing are some of the earliest industrial areas in Sweden, from the 17th century onwards. The remains of lime kilns, lime barns, old piers, etc. can still be found. There are also shipwrecks to be found on the seabed as the transportation of limestone sometimes resulted in fire.[36]

With the island's growing importance for transport and trade, there was an increased need for larger harbours and larger ships. A mill, a sawmill and a water-powered facility for wool processing were established in Lummelunda. At the end of the 17th century, a blast furnace and hammer for the processing of iron ore to bar iron were added. In order to maintain the blast furnace and the hammer, great quantities of wood and coal were needed, which farmers in the area could supply. The iron ore was transported from Utö, amongst other places. However, the iron works were not particularly successful and shut down at the beginning of the 18th century.[37]

There have always been harbours of various different sizes along the coast of Gotland. Most of them were called fishing villages and the larger ones were known as rural harbours. The difference between fluctuated and was not clearly defined by the authorities. When Gotland was transferred from Denmark to Sweden in 1645, the Swedish authorities tried to stop trade outside of Visby but it was soon resumed. During the 20th century, economic associations started up in the fishing villages.[38]

*Image 8. Lighthouses on Östergarnsholm  Photo: Tor Sundberg*

## 4.3 Maritime remains

The low salt content in the Baltic Sea and the absence of marine worms provide very good conditions for the preservation of wood.  The maritime remains are therefore unusually well-preserved in relation to the situation in many other oceans.  Among the remains found under the water surface are wrecks from different time periods, remains from piers, wharves, bank revetments, mooring devices, etc.  We currently know the locations of approximately 140  wrecks and ship remains. There is also information about the positions where ships sank, even when no actual wreck has been confirmed.  Records of the sinking of ships only started to be kept in the early 19th century.  Therefore, several thousands of years of maritime history are lying on the bottom of the sea, waiting to be discovered. A few examples have come to light. When the golf course at Kronholmen was being reworked in 1995, wooden sections which had once been part of a medieval ship, a ”cog”, were discovered. At the time, it was not known that the place had been an approach channel, situated right next to the  find location.  In the summer of 2011, another cog was found, this time in the sea, between the two Karlsö islands.

Remains from the fishing of ancient times can be viewed at Sjuströmmar in Boge and in Västergarn where large fish chutes bear witness to an earlier method of catching fish. Further traces of fishing can be seen in the large number of posts for seine fishing and moorings which are today up on land. In addition to harbours and good approach channels, seafaring also required navigation points such as sea-marks, light poles, beacons and lighthouses. Remains from seabird hunting can be seen in the form of hides comprised of low stone circles.[39]

## 4.4 The dawning of tourism

As early as in the 17th century, priests and school teachers began recording ancient remains and other things of antiquarian interest. At the end of the century, educational trips started to be arranged to Gotland. Carl Linnaeus and C.C.G. Hilfeling visited the island on several occasions and published books about their experiences.

In the middle of the 19th century, steamboat traffic had developed and travelling became both cheaper and quicker.  Industrialism and the transition to a monetary economy means that more people can afford to travel. Even if the days of mass tourism would not arrive until the 20th century, interest in travelling for enjoyment, relaxation and education is awakened in an increasing number of people. The coast offered bathing and other recreational pursuits which is why the importance of operating by the coast increases in pace with tourism.[40]

In 1865, the Gotland County Governor has had enough of the poor boat service and therefore takes the initiative to start a shipping company in order to improve communications. Gotland also became well-known when the princess Eugénie took up residence at Fridhem in the late 19th century. Gotland’s tourist association was established in 1896 and a hotel and guest houses were built, including the tourist resort Snäckgärdsbaden.

In the late 1930s, Sweden introduces legislation providing the right to four weeks of holiday and tourism starts to take off in a big way.  Guest houses for bathers were built on both the west and east coasts and this continued up until World War II.[41]  At the end of the 1930s, the shipping company Ångfartygsbolaget Gotland finances the moving of an Iron Age building foundation from Dalhem to Snäck so that holidaymakers could have easy access to Gotland’s  cultural environment.

# 5 The coastal zone and the marine environment

The area that constitutes the border between land and water is referred to as the coastal zone. Due to the many options available, coastal areas all over the world house a large percentage of the world's population and they are the livelihood of a great many people. The level of exploitation is therefore normally higher in these areas than inland, which means that many interests and activities coincide. Ecological, cultural and recreational treasures are therefore often forced to be balanced against the interests of exploitation and financial developments. This is one of the reasons why coastal zone planning is often complex and requires careful consideration.[42]

## 5.1 The coastal zone is in demand

Due to high population growth and rapid economic development, the coastal zone is subject to many types of threats. Several ecosystems have been adapted to suit humans. These changes have often meant that the capacity of the ecosystems to supply goods and services decreases which will, subsequently, affect people's lives. Typical threats to the ecosystems of the coastal zone are the alternative use of land, buildings, infrastructure, industries, invasive species and the depletion of natural resources, for example, overfishing.[43]

Many of Europe's coastal zones have problems with the loss of cultural, socio-economic and natural resources. This is partly due to the effect of climate changes through increased flooding and erosion. Despite this, coastal planning and decisions on developments in coastal zones are made on a sector basis. This in turn creates inefficiency and conflicting interests that in the long term will mean that the chances to create more sustainable development in the coastal zones will come to nothing.

In order to improve this situation, the European Parliament and Commission adopted a recommendation in 2002 entitled Integrated Coastal Zone Management (ICZM). This defines principles that should apply in connection with planning in coastal zones. The recommendation highlights the importance of the planning being based on confirmed and joint knowledge, that decisions shall be sustainable in the long term and be made with consideration taken to all points of view, that land owners shall be involved in preventive efforts and that the conditions on both land and sea shall be preserved.[44]

Even though sustainable development is frequently used in various political contexts, both nationally and internationally, financial aspects still seem to be given more consideration that environmental issues. For example, in planning processes, actual and tangible values are often used to describe the environment, such as habitat areas, biodiversity and protected areas. Abstract values such as social and cultural aspects are more difficult to measure and are therefore normally paid less attention.[45]

The difficulties involved in integrating these values in planning processes often result from conflicts between policy objectives and plans or from operational work. In order to improve the process of sustainable development in planning processes, the landscape concept, which relates to the socio-cultural and ecological dimensions of locations and regions, can function as an important tool.[46]

## 5.2 The coastal zone of Gotland

The Swedish coastline is long and the variation between different habitats is great. For example, the salt content in the water varies, from sea water in the northern Skagerrak, to almost fresh water in the Gulf of Bothnia, and this leads to very different physical conditions along the coast. As a result of the sinking salt content along the coast, the composition of species changes. In many cases, plants, algae and fauna adapt in a unique way, based on the prevailing conditions.[47]

The coasts of Gotland are, in addition to the national coastal protection legislation, protected by a nature reserve that runs the length of the coast. The reserve was founded in 1993 and covers a total of approximately 10,400 hectares. As opposed to other nature reserves, the coast of Gotland has no regulations and is not administered by the County Administrative Board, but by the relevant area's land owners. The reserve supplements the coastal protection legislation and provides the County Administrative Board with a unique opportunity to monitor all changes in the coastal area.

## 5.3 The marine environment around the coast of Gotland

The marine environment of Gotland differs significantly from the rest of Sweden and is of great importance to many species in the Baltic Sea. Outside the coast line, sand beds free from vegetation are common. The beds serve as spawning areas for many types of flatfish, the island's shallow bays form important reproduction and nursery areas for many species of fish living on the coast and on impermeable rocks, bladder wrack, red algae and blue mussels grow. The isolated location of the island means that many species are completely dependent on the function and intact condition of these reproductive environments.

The origins of Gotland date back approximately 400 million years to a time when Sweden was located near the equator. The present shape of the island was primarily formed by the last ice age. The western coast is characterized by steep rocks, where the cliff tops seem to hover over the deep sea which surrounds them. As opposed to the western side, the east coast is primarily flat with shallow beaches. The beaches often consist of rock and pebbles, e.g., shingle beaches, beach ridges, stack areas, but there are also long sandy beaches.[48]

The marine environment around Gotland houses several important habitats that are crucial for the ecosystems of the Baltic Sea. In marine environments, the abiotic factors are of great importance for the species to be found in a certain marine environment. The brackish water is the single greatest determining factor for the composition of the species, but wave exposure also has great importance for the composition of marine species around Gotland.

Wave exposure is a measurement that describes the effect of waves on a specific location and which affects the composition of species of invertebrates on shallow beds and on the shore. Investigations[49] show that *moderately exposed* sea beds have the greatest prerequisites for high marine biodiversity. Around the coast of Gotland, 60 per cent of the marine environment is assessed to fall into that category. The environments with the lowest diversity are *highly or extremely highly protected environments (see diagram)*. These environments can be found at the innermost end of bays or behind reefs and islands. Shallow protected environments are of great importance to coastal species of fish and the environment was assessed to be of great value to our GIS model.

**WAVE EXPOSURE AROUND THE COAST OF GOTLAND.**

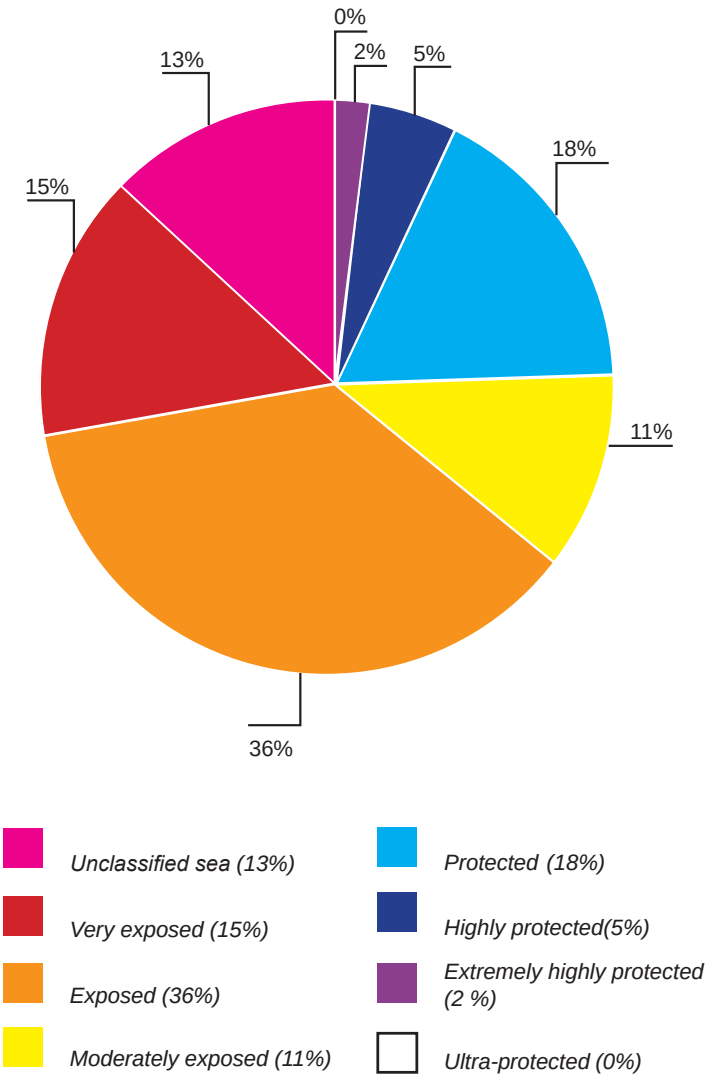



*Diagram 1. Wave exposure around the coast of Gotland.*

**DIVISION OF BEACH TYPES AROUND THE COAST OF GOTLAND.**

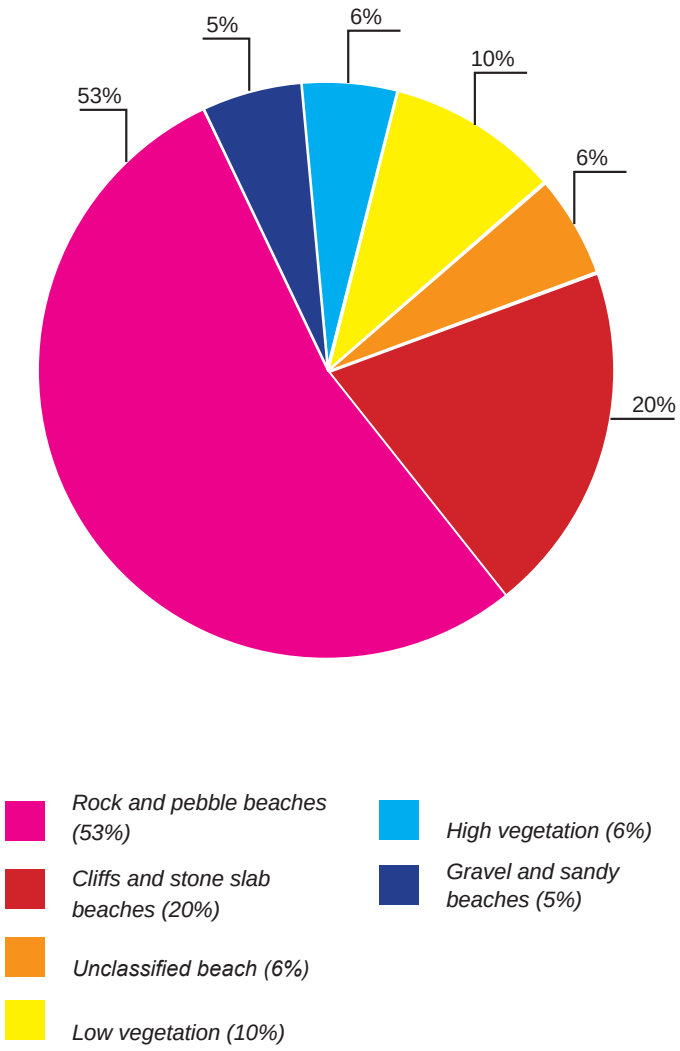



*Diagram 2. Division of beach types around the coast of Gotland.*

The topography and geology of an area is also of great importance for which species are found in a certain location in the marine environment. The division of different depths around Gotland shows that a depth of 50-100 metres is the most common. Greater depths can be found primarily to the east and northwest of Gotland. Shallow environments within the photobathic zone (< 10 metres), i.e., the depth at which most plants and algae are best able to absorb sunlight, only constitute approximately 6.5 per cent of the total marine area of Gotland.[50]

Sea beds and beaches along the coast of Gotland are made up of all types of composites. The diagram above shows that more than 50 per cent of the beaches are rock and pebble beaches whilst 20 per cent are cliff and stone slab beaches and 5 per cent are gravel and sandy beaches.[51]

The vegetation in the beach zone is governed by which type of sea bed is functioning as a substrate. In addition, the level of wave exposure is of great importance for which type of sea bed vegetation exists. In exposed locations on hard bottoms, primarily red algae and bladder wrack occur for example. Bladder wrack has difficulties competing with other species when the location is too exposed and when the depth increases. This means that the vegetation from 3-20 metres on hard surfaces is often dominated by red algae. At depths of over 15 metres, the vegetation decreases considerably and instead, blue mussels will take over on the seabed. On other types of bottoms, mussels occur in lower densities.[52]

The more shallow soft bottoms, 0-10 metres, are often dominated by vascular plants. These types of bottoms are primarily common on the east coast of Gotland. Eelgrass will often grow there together with other aquatic plants such as sago pondweed and clasping-leaf pondweed. In more protected bays, charales may be common. On sandy soft bottoms at depths greater than 10 metres, there is a species-rich bottom fauna with several species which are sensitive to disturbance. These bottoms are often completely devoid of vegetation but it is not unusual to find free-living algae.[53] These algae can host a fauna as rich as that of attached algae.[54] Sand bottoms free from vegetation also have a large value for reproduction of several flatfishes.

*Image 9. Mussels in Baltic Sea. Photo: Annika Broms*

## 5.4 Common marine species

**Bladder wrack** (*Fucus vesiculosus*) grows on hard substrates from the beach zone at a depth of a few metres. The species has difficulties competing when its location is too exposed to waves and the wind. Dense and healthy populations of bladder wrack can primarily be found on the flat rock bottoms before the water gets too deep. The bladder wrack is of great importance to a number of other species in the Baltic Sea ecosystem. In one cluster of bladder wrack, there may be around 20 to 30 species of invertebrates and grazers. The most important grazers are different species of isopods which eat both seaweed and filamentous algae, different types of gastropods, which primarily eat microscopic algae on the surface of the seaweed and amphipoda, which are also important grazers in the bladder wrack community. Species of fish which often occur in bladder wrack environments are, for example, various species of bullhead, goby, viviparous blenny and stickleback (three-spined stickleback and sea stickleback).[55]

**Blue mussel** (*Mytilus edulis*) is one of the most common species in the Baltic. It grows on both hard and soft surfaces down to a depth of 30 metres.The blue mussel needs good oxygen circulation and it has few competitors. It eats plankton and other small particles that is ingests as it filters great quantities of water. Through its great filtration capacity, the mussels have an important ecological function in coastal areas where they connect the plankton to the bottom system by recirculating nutrients. The long-tailed duck and eider are very dependent on blue mussels for food, several flatfishes also have blue mussel as their main food source.[56]

**Eelgrass** (*Zostera marina*) commonly occurs on the east coast of Gotland at a depth of up to 8.5 metres. The greater depth indicates good water quality. Eelgrass is the dominant seaweed in Sweden and forms species-rich ecosystems with high primary and secondary production. Several types of invertebrates thrive in the eelgrass and you can often find amphipoda, baltic isopods and *small gastropods*. The types of small fish primarily found are the three-spined stickleback, sand goby, flounder and herring. Larger types of fish are perch, zander, pike, salmon, sea trout and cod. Eelgrass is listed as a threatened/diminishing environment and is part of the Natura 2000 habitat Sublittoral sandbanks (1110).[57]

**Brown algae** (*Pilayella littoralis*) belong to the filamentous algae that have benefited from increased levels of nutrients in the water. It has become evident that the carpets of algae that brown algae form on rock bottoms in the Baltic Proper, effectively prevent new bladder wrack plants from attaching to the bottom. The reason is partly purely physical, in that the fertilized seaweed eggs get caught in the threads and do not reach the rock, and partly chemical in that the brown algae exude substances that reduces the survival of the new bladder wrack plants.[58]

## 5.5 The environmental status of the sea

In deep basins around Gotland, there are large areas of oxygen-free bottoms, which have a negative effect on the marine environments. The existence of the oxygen- free bottoms is due to a long period of excessive nutrient discharges of nitrogen and phosphorus into the entire Baltic Sea. The Baltic Sea's ecosystem, with its slow blending of water masses, makes the sea particularly sensitive to the eutrophication.[59]

Outside the coast of Gotland, the samples taken of bottom fauna and the spread of algae and plants show that the environment has a relatively healthy status. Several examinations[60] have been conducted during the years 2006 - 2010 around the coasts of Gotland, both on the subject of water vegetation and on bottom fauna. The results indicate that the overall status of the marine environment is healthy and that the open stretches of coast are by and large in a good condition. Closer to the coast and especially in shallow bays however, the environmental status gets worse; the amount of algae fouling has increased and the spawning habitats for many species of fish have deteriorated.

The background to this is partly the increased amounts of nutrients such as nitrogen and phosphorus but the overfishing of important species of fish has also had a negative impact on habitats near the coast. Furthermore, it is the inner parts of the bays that are more affected than the outer and their status is often unsatisfactory. In general, the coastal water of Gotland is still of a good quality. A clear indicator of good water quality is the proliferation of bladder wrack and eelgrass. Soft bottoms along the open coast of Gotland are also of a good quality.

*Image 10. Cliff edge by the sea. Photo: Magnus Martinsson*

# 6 Coexistence of many interests

Gotland is no exception when it comes to attractive coastal areas; there is great interest in the region's resources.

## 6.1 Buildings

In 1995, Visby was designated a UNESCO World Heritage site. "Visby is an outstanding example of a Northern European walled medieval trading city with an exceptionally well-preserved city environment and highly valuable older buildings that vividly illustrate this type of significant human settlement, through both its form and function".[61] In 1976, the entire city centre of Visby was registered in the Archaeological Sites and Monuments database as an ancient monument. The value of the buildings is obvious with consideration to the UNESCO designation but there is also great cultural and historical value to be found below ground, from an archaeological perspective. Here there is evidence that human beings have lived and worked in Visby from the Stone Age up until today. This puts demands on the antiquarian authorities to safeguard them, but at the same time not to prevent development. Exploitation sometimes creates a conflict in this balance of interests.

In general, the greatest interest in construction development is along the coast. This is illustrated below in a map of Gotland which indicates the number of applications for building permits received during 2005-2007 and where they are located. Please note that this is not the same as the number of approved applications.

*Image 11. The old pharmacy in Visby. Photo: Lars Bäckman*

*Image 12. The number of applications for building permits received by the Building Committee, Region Gotland during 2005-2007 and where they are located geographically. Map from Region Gotland.*

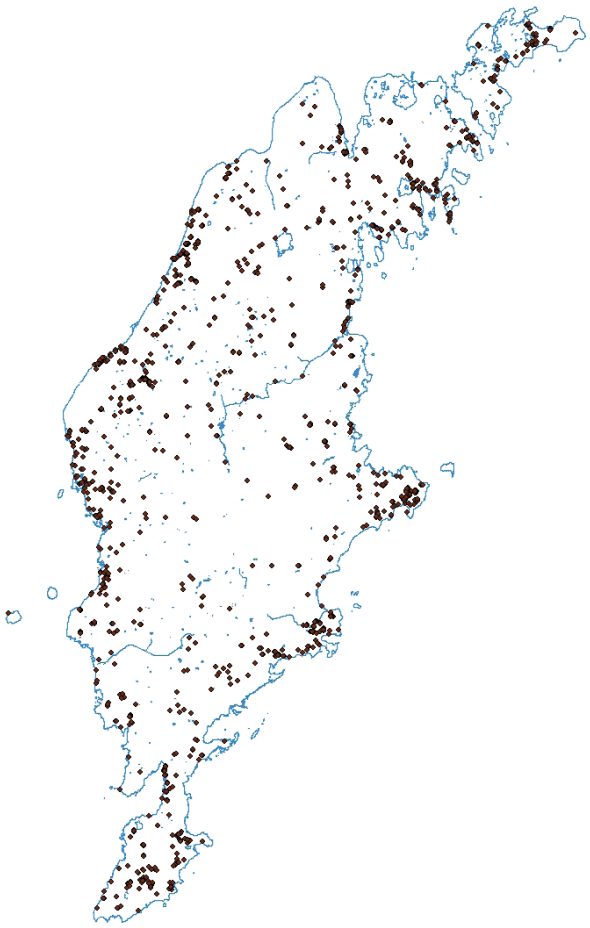


*Image 13: Aerial photograph of the wind power farm at Näsudden, southwest Gotland. Photo: Gunnar Britse*

## 6.2 Wind power

The Swedish Energy Agency's decision regarding criteria for highlighting the national interest for wind power production meant, for Gotland, that the entire country was included, on land as well as out at sea. In Gotland Municipality's s general plan Bygg Gotland (Build Gotland)[62], the prerequisites for winder power production have been particularly highlighted. The general plan has guidelines for balancing with other interests such as nature conservation, outdoor activities and the cultural environment. However, with regards to the coastal zone, it is noted that it is unlikely that any significant area of land will be claimed for wind power production in the next few years, with the exception of already established wind power plants and those constructed out in the sea. Construction at sea has been slowed down by a lack of financial resources and technical developments and this means that it has, in principle, completely stopped. But if the problems with financing and technical testing are resolved, further construction of wind power plants at sea is very likely as it has great potential and provides significantly more energy per installed MW than land-based plants.

Svenska Kraftnät (Swedish national grid) is planning a new cable connection between the mainland and Gotland. It is necessary if more old wind power plants are to be replaced with new, more powerful plants, since the present grid is currently used to its full capacity. In connection with the installation of wind power plants, there will also be new or rebuilt roads, cable excavation work, increased traffic, noise, etc. which will also have an impact on the landscape.

The closest thing to a wind power farm on Gotland today is Näs, in southwest Gotland; see the photo above.

Näsudden embodies the present day's new claims for land use and future conflicts.At the same time as the area functions as an important place for wind power production, the beautiful coastal area with its many natural assets, entices people to purchase holiday homes here. In addition to recreational values, there is also a living cultural community and a small-scale farming community, both of which make their own, further demands. In light of this, a usable and all-encompassing planning foundation is naturally of great importance for Näsudden and similar areas in the coastal zone, so that they can continue to satisfy all the different parties who are interested in the landscape.

## 6.3 The changes in fishing and homes near the beach

Fishing has for a long time been of great importance for the inhabitants of Gotland. In days gone by, many were dependent on both agriculture and fishing for their living. Archaic names and the many different expressions for various places (”rev, skär and uddar”, reefs, islets and headlands) indicate the importance and long tradition of fishing. Before the development of modern fishing, fishing for baltic herring had been the most important fishing around Gotland. With the development of the engine and its use on boats and the building of piers etc., fishing could constitute a person’s main income. From a historical point of view however, fishing did not survive long as a source of income. Today, non-commercial fishing primarily comprises fishing with nets near the coast. The most common fish caught are flounder, salmon, trout, cod and baltic herring. Previously, fish like whitefish, perch and pike were also caught. The populations of predatory fish living near coasts however, have decreased dramatically since the 1980s. After many years of overfishing in the Baltic, the effect is that many populations of fish have decreased around the coasts of Gotland; large fishing vessels catching large quantities of fish can be seen further off the coast. The fishing tradition in Gotland has successively lost its position.

Changes in fishing naturally also affect the use of the beach huts. As early as 1932, Koviks Fiskarförening (Fishing Society) decreed that it was not permitted to rebuild beach huts into holiday homes.[63] In the 1980s, researchers established that the cultural heritage of the coastal zone was under threat. Exploitation of various kinds, such as tourist resorts and irrigation dams occurred in areas of high cultural and historical value.[64]

The fishing villages are not protected by law, but they are included in the coastal protection regulations. The coastal protection regulations were adopted in the 1950s in order to prevent over-exploitation of coastal areas as well as to preserve public access to beaches and water for outdoor activities. The coastal protection regulations are part of the Environmental Code and they also include some buildings. Consequently, exemption from the coastal protection regulations is needed when the use of something is altered, e.g. redevelopment etc. On Gotland, there is only one fishing village that is listed and protected in accordance with the Act concerning Ancient Monuments and Finds.

## 6.4 Harbours and maritime traffic

Maritime traffic to and outside of Gotland is constantly increasing. Visby harbour is the hub of communications and transportation to and from Gotland. Several daily calls are made between Visby, Nynäshamn and Oskarshamn. There are also a large number of cruise liners coming into Visby harbour during the summer season. In 2009, more than 1,600,000 travellers chose to travel with the ferry company, Destination Gotland. However, the number of visits being made by major cruise liners is decreasing as there is no dock large enough to accommodate them. A new cruise ship dock in Visby is planned for 2012. Activities in Slite harbour on the east coast of Gotland have increased over the last few years as the harbour has functioned as a loading dock for the gas pipeline through the Baltic. The Russian company involved has also financed the renovation of the harbour.There are also plans for a new extension to Klintehamn, in west Gotland, in order to relieve some of the pressure of heavy transport from Visby harbour.

A comparison between aerial photos from the pier inventory of 2003 and the current facilities show that piers that were previously smaller have been extended for larger boats. The investigation clearly indicates that the amount of dredging has increased. The inventory also shows that the facilities (piers, fishing villages, harbours) in the coastal zone constitute a relatively small part of the total coastline; 92 per cent of the beaches on Gotland have not been exploited through facilities in the water.

*Image 14. Catches of baltic herring and European sprat in Ronehamn. Photo: David Lundgren*

# 7 Threats to the marine environment

The marine environment and the cultural heritage in the coastal zone are constantly subject to trials and challenges as the usage of the area increases.

## 7.1 Enemies of the maritime environment

Eutrophication is a threat throughout the Baltic, both on an international and local scale. An increase in eutrophication has meant that the growth of many fast-growing annual algae has increased, at the expense of perennial algae such as the bladder wrack. The effect is an increased biomass that accumulates at a greater depth for biodegradation, processes that often lead to dead sea beds. Future climate change is a large-scale threat to the marine environment. Increased volumes of rain and a warmer climate will entail a change that can have a great impact on the composition of species and the entire marine ecosystem.

Overfishing of important species of fish has had major consequences for the marine ecosystem, e.g. the effect of the loss of predatory fish permeates the entire nutrition cycle and finally contributes to the increase in filamentous algae along the coasts.

Increase maritime traffic brings with it constantly increasing threats to the marine environment and the coast of Gotland. Maritime traffic in the Baltic Sea is perhaps the single major threat; the more boats that are crossing the Baltic, the greater the risk of a serious accident. Such an accident could have devastating effects on the entire Baltic ecosystem. According to figures from the Swedish Maritime Administration, 31,390 ships passed the east coast of Gotland during 2009. The figure for the same period on the west coast is 16,121 ships.

In days gone by when we had less knowledge of the sea, it was often used as a dumping ground. Many tons of rubbish and other waste are lying on the seabed and this will be an encumbrance for the Baltic Sea and the environments around Gotland for a long time to come. When shipping increases, so do emissions and the littering of the Baltic. Within a few years, there will be a ban on recreational boats dumping the contents of their toilets, which is positive. But out at sea, problems remain where many cruise liners and cargo vessels can dump untreated waste water without any consequence.

Other threats to the marine environment are, for example, the increased effect of fishing equipment, increased boating, damages caused by anchoring, increased water scooter driving and noise, particularly in sensitive areas e.g. in fish reproductive and nursery areas.

The biggest threat to the cultural values of the coastal zone is ignorance. Previous chapters have already mentioned this problem. Another threat is the looting of wrecks or other finds at sea. When it comes to marine remains, certain places have been incorrectly marked. There may be several different reasons for this – to protect the site from diving and possible looting, or to keep the place secret. Opinions are divided as far as public information regarding wreck sites is concerned.

Maritime traffic, fishing and dredging can also spell danger for ancient remains. Unless there is verified information, the losses caused by exploitation will never be known. Trawling, dredging and anchoring can lead to major land encroachments on the sea bed and, at worst, completely destroy any wood wrecks or other remains.

Region Gotland is planning to sell a number of municipal harbours which could mean a conflict between cultural values and development in the harbour areas. Work to safeguard maritime remains has been carried out in a number of places over the last few years. Another larger examination took place outside Visby harbour. Since the modern cruise liners cannot call at the harbour, they drop anchor. This entails great damage to the seabed when an anchor is dragged along the sea bed; sometimes it rips up the sea bed for several hundred metres. The purpose of the examination was to see if parts of the Danish-Lübeck fleet that was shipwrecked off Visby in the 16th century, had been damaged.

# 8 Integrated GIS model for planning and public planning in the coastal zone

The principal purpose of the project has been to develop a GIS model that will facilitate planning and public administration. The focus of the work has been the coastal zone of Gotland, but the tool created can be applied to other areas, as long as the necessary information exists.

The software used is ArcView 9.2 and, in the final stages, 9.3.

## 8.1 Integrated GIS model

The objective was to create a model that indicates ecosystem services in the coastal zone. The information is intended to be comprehensive and to include areas that have not yet been inventoried. The initial work involved producing a model in which the preservation values in the landscape were classified. Different natural habitats were chosen as the starting point for the model.

The border for the coastal zone was determined at 1,000 metres inland from the shoreline as well as 1,000 metres out at sea from the shoreline, in other words, a total width of 2,000 metres. This demarcation, which is larger than the area referred to in the legislation, was chosen in order to protect the coastal zone, and also because this is where the greatest pressure from exploitation can be found. The coastal protection varies between 100 - 300 metres in the cases where the County Administrative Board have decided on an expansion of the general coastal protection. The area around the coast of Gotland that is highlighted as a coastal protection area is more or less the same as the nature reserve Gotlandskusten. The national interest in outdoor activities, in accordance with Chapter 3 of the Environmental Code, runs along the entirety of the coast of Gotland, 500 metres from the shoreline.

The map layers used for this project have been adapted to the demarcated areas and those further inland or out at sea are not included (”clip” or ”mask” have been used). However, this does not exclude the possibility of including these areas at another time, should interest exist. The pixel size used when the vector layer has been converted into raster layers is 5x5 throughout.

The inventories made which are added as map layers are often of very good quality but overlap each other and partly indicate the same thing, albeit in different ways.

In connection with the map layers being laid on top of each other in order to include more values in the same GIS image, there may be double ”points” for the same value if they are visible in several layers. One example of this problem is the spruce mire habitats which are shown as wet forests. These also appear in the layer for wetland inventory since this shows all types of wetlands, including forests. If the map layer for key habitats is also added, it will show small forest areas with high natural values, which wet forests often are. The model has taken this issue into consideration and as much as possible, the overlaps are compensated so that exact copies do not occur.

## 8.2 Classification of conservation values

Four classes were used, excluding the class *zero* based on similar divisions used in previous inventories.[65] The maximum value will never exceed the value 4, even when the ”basic classification” and the supplementary classification are summarized.

Conservation values in the model means that there is a high biodiversity in natural and cultural values. The arable land is therefore not assigned such a high value.

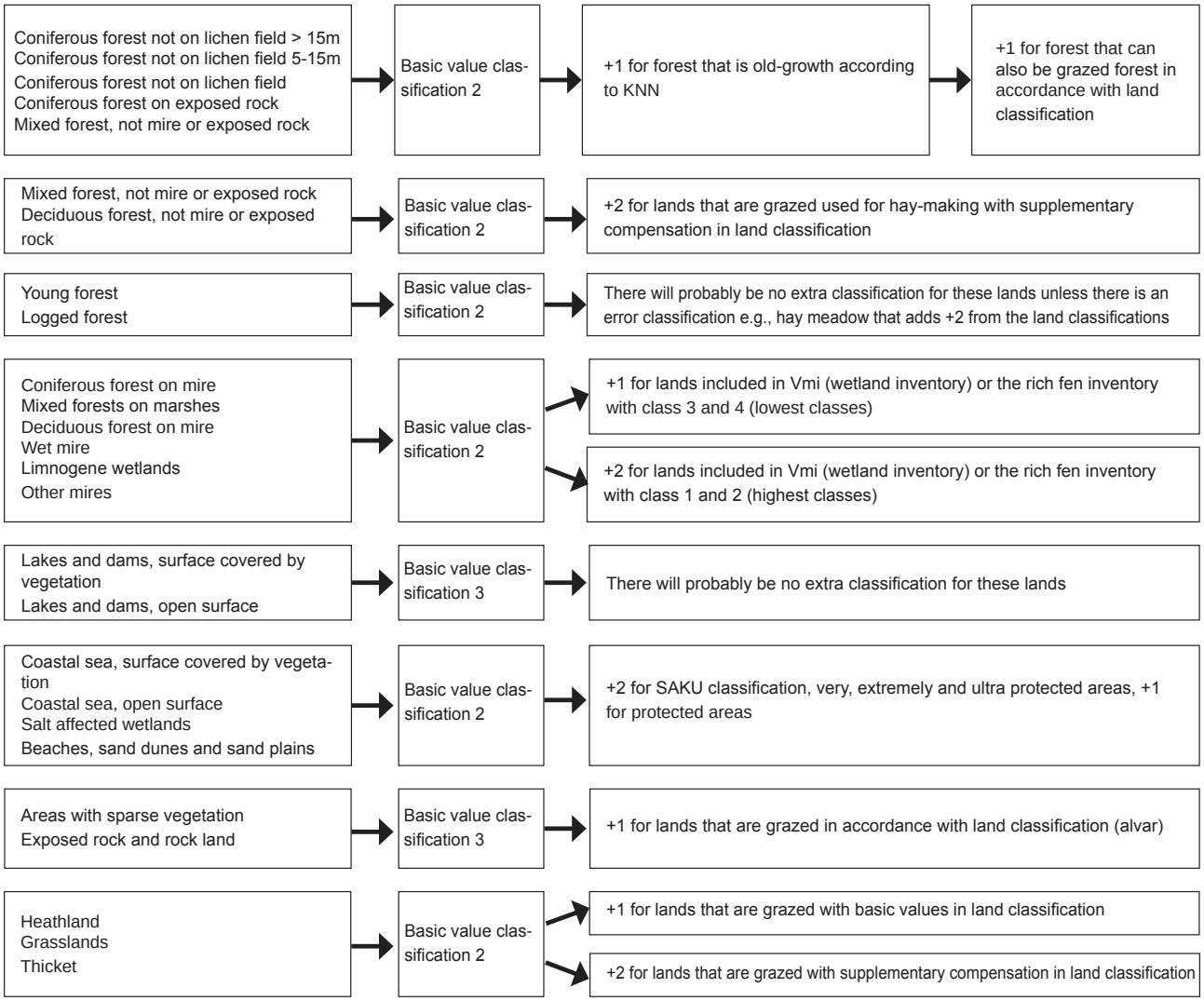
The assessment of what class a habitat shall be assigned is based on the County Administrative Board´s collected knowledge of biodiversity within each habitat.

Initially, a basic classification of the map layer Marktäckedata, *Land cover data*, was carried out, on a scale of 1-4; see table 1. Thereafter, the basic classification was reduced for the areas in the map layer that were covered by supplementary map layers. Via these supplementary layers with more detailed information, some of the error sources could be minimized and the more valuable areas could be identified in a more correct manner and be assigned a higher classification. As a supplementary map layer, kNN-Sverige land classes 2011, wetlands and rich fens were used, in addition to SAKU. All layers are described in chapter 8.3. Pasture lands are included in order to achieve a more accurate division of habitats, but also because most land maintained by grazing or haymaking has a higher biological value than unclaimed land.[66]

| Habitat: | Class: |
|---|---|
| All types of forests | 3 |
| Young forest and clear-felled area | 2 |
| All types of marshes, wetlands, lakes and seas | 4 |
| Beaches etc. | 4 |
| Areas with sparse vegetation and rock outcrops | 4 |
| Heathland and pastureland | 3 |
| Thicket | 2 |
| Fruit and berry cultivation | 2 |
| Gravel and sand pit | 1 |
| Camping site and recreational buildings | 0 |
| Golf course | 1 |
| Sports facilities etc. | 0 |
| Airfield | 1 |
| Airports, landfill sites, ports, industrial areas, etc. and other mineral extraction production sites | 0 |
| Non-urban park | 2 |
| Urban green areas | 2 |
| Rural settlements and villages and towns of various sizes, densely populated city structures | 0 |
| Road and railway networks with surrounding areas | 1 |
| Arable land | 1 |

*Table 1. Introductory basic classification of habitats, prior to correction of the basic value for the areas*

In addition to habitats and supplementary habitat inventory for forests, wetlands, pastureland and seas, more information is needed in order to obtain a more complete picture of the conservation values. Endangered species such as plants, animals, mosses, fungi, breeding birds and insects are an important parameter for conservation values. The more endangered species an area harbours, the more important it is to conserve the area, in particular if the level of threat is high. It is also important to include ancient remains in order to be able to understand different eras in our history, as well as streams which are very important since flowing fresh water is a vital constituent for most organisms.




There will probably be no extra classification for these lands unless there is an error in the classification .e.g., hay meadow that give +2 from the land classifications

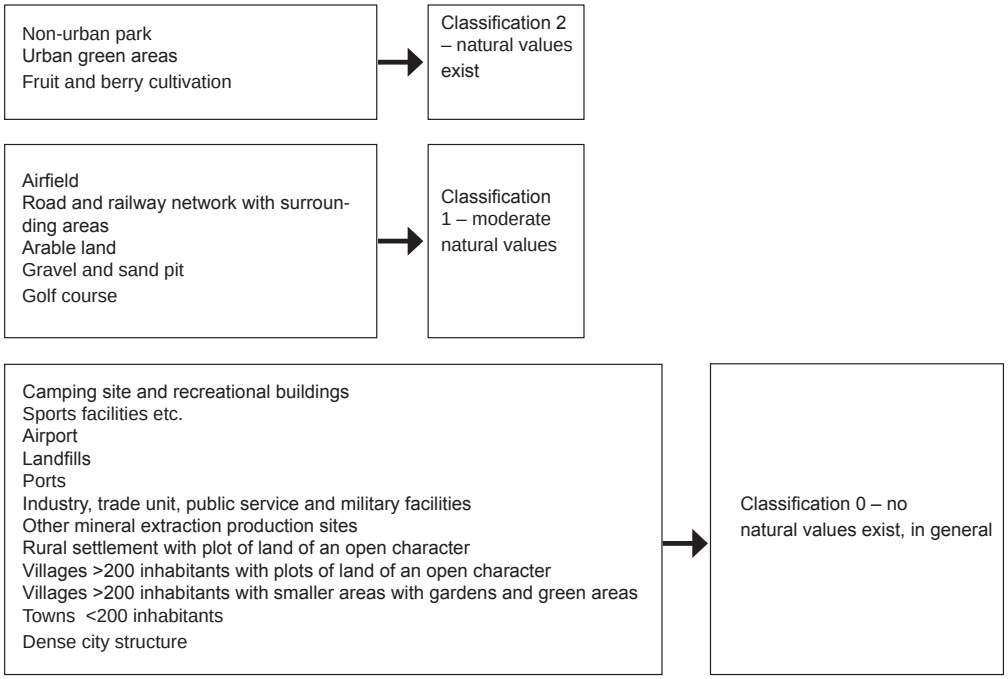



*Diagram 3. Overview image of the classification of habitats with corrected basic values as well as supplementary classification for supplementary layers.*

Example of how the classification was carried out: Pasturelands were initially awarded basic classification 3, i.e., three points. After a supplementary map layer (land classification 2011) was added, the initial value was decreased to two points. The lands that have been classified as pasturelands and hayfields with higher biological and cultural historical values based on the supplementary compensation from the EU subsidies were given another two points. This meant that the pasturelands that were initially given two points received another two points if they were considered to be of extra value. The sum total for the most valuable pasturelands was then four points, i.e., they were placed in the highest class, class 4. Land areas less than five hectares, e.g. the hayfield that was erroneously classified as arable land will receive fewer points (one point for arable land + two points for supplementary compensation = three points). This may be considered too low but the correction for the supplementary layers at least gives the category three points instead of the one point that it would have been awarded if it had remained as arable land.

## 8.3 Map layers for conservation values

***Marktäckedata, Land cover data. Map layer from Lantmäteriet - the Swedish mapping, cadastral and land registration authority, year 2000. Scale 50,000 – 100,000.***[67]

In order to achieve an all-encompassing map layer for all land types along the entire coastal zone of Gotland, information from Lantmäteriet - the Swedish mapping, cadastral and land registration authority was used, via the map layer *Land cover data*. In the rest of Sweden, some locations have been subject to more detailed vegetation mapping, but these are missing on Gotland. In order to see if the map layers used still provide a good enough image, a trial with aerial photo interpretation has been conducted for a specific area of the island, the parish of Östergarn. The trial was conducted in collaboration with the project Landscape strategy for Östergarnlandet and was conducted based on EU's Natura 2000 mapping of habitats. See more under chapter 8.3, heading: Natura 2000 habitat mapping.

The division of habitats used in the map layer is decided by Lantmäteriet and shown in table 2. These habitats have then been given a basic classification in accordance with table 1. Only the habitats existing on Gotland are included.

| **Habitats in accordance with ground cover data (existing on Gotland)** |
|---|
| Coniferous forests not on lichen fields 5-15 metres |
| Coniferous forests not on lichen fields> 15 metres |
| Coniferous forests on rocky outcrops |
| Coniferous forests on lichen fields |
| Coniferous forests on marshes |
| Outcrops and rocky land |
| Pasturelands |
| Mixed forests on marshes |
| Mixed forests, not on marshes or on rock outcrops |
| Wet marshes |
| Thicket |
| Camping site and recreational buildings |
| Landfill |
| Non-urban park |
| Airfield (grass) |
| Airport |
| Fruit and berry cultivation |
| Golf course |
| Gravel and sand pit |
| Port areas |
| Heathland (except grassy heath) |
| Clear-felled area |
| Sports facilities, shooting range, race track as well as horse-racing facilities and greyhound racing track |
| Industry, trade units, public services and military facilities |
| Coastal seas and oceans, surface covered by vegetation |
| Coastal seas and oceans, open area |
| Rural settlement with plots of land of an open nature |
| Limnogene wetlands |
| Deciduous forest on marsh |
| Areas with sparse vegetation |
| Villages with more than 200 inhabitants and with larger gardens and green areas |
| Villages with more than 200 inhabitants and with smaller gardens and green areas |
| Villages with less than 200 inhabitants |
| Salt-affected wetlands |
| Lakes and dams, area covered by vegetation |
| Lakes and dams, open area |
| Beaches, sand dunes and sandy plains |
| Dense city structure |
| Young forest |
| Urban green areas |
| Road and railway networks with surrounding areas |
| Arable land |
| Other marshes |
| Other mineral extraction production sites |

Table 2: Habitats than can be found in the map layer *Land cover data* in Sweden. Only habitats found on Gotland have been used in the model.

The map layer *Ground cover data* is based on interpretations of aerial photographs made by computer. This means that there may be false interpretations built into the material. One example of this is small areas of one to five hectares that may be included in larger areas, e.g. the hayfield that may be included in arable land. Since the hayfield has great biodiversity values with its often unique plants and insects, it is important that these are properly visible in the map layers. They are also important for the cultural environment and recreation, which makes them even more important to include in the model in order to comprehensively illustrate all of the coastal zone's values.

Aerial images may be difficult to interpret in more than one way which can lead to false assessments. Hayfields, for example, are half open lands with mostly deciduous trees. In an aerial photograph, it can look confusingly similar to a clear-felled area. Pasturelands in general are difficult to interpret from aerial photographs. It may be difficult to determine whether or not they are being grazed, but the amount of trees can also cause issues. If the pastureland houses many trees, it can easily be interpreted and classified as a type of forest.

The age of the material may also cause an error in source. The basic material is from the year 2000 and several types of land have changed since then. Forest land, for example, changes relatively quickly, as a result of and continuous growth. Pasturelands can also change through conversion into arable land or by becoming overgrown. To compensate for these possible errors in source, the model has been supplemented with several map layers which contain more information from additional inventories.

### *Natura 2000 habitat mapping. Map layer from County Administrative Board, 2011.*

In collaboration with the County Administrative Board´s project Landscape strategy for Östergarnlandet, a detailed habitat inventory was conducted, based on aerial photographs on the computer, taken in 2007 and 2010, scale 1:2,000 - 5,000. The map layer is only produced for Östergarn parish but can be expanded, subject to interest and resources. Several field visits were made.

The resolution of the aerial photographs from 2010 is very good and based on these, the habitats have been assessed with relative certainty. Protected areas have previously been divided in accordance with the same methodology. The inventories made in meadowlands and pasturelands have provided support for the assessment.[68]

The habitats are divided in accordance with Natura 2000 habitat, the EU's network for nature areas. Within this network, habitats that have been assessed to be extra important are listed.[69] To complement this, land areas that are not classified as Natura 2000 habitats, e.g., car parks and fields, have been included. These have then been collected in a group and entitled 'other areas'.

### *kNN 2005 – Sverige. Map layer from Swedish University of Agricultural Sciences, 2005.[70]*

The map layer contains information on age, height, type of wood and wood storage for Sweden's woodlands. The information has a high level of detail and is displayed as raster data with a resolution of 25x25 metres.

A forest with a high biological value is often a forest with long continuity. However, it may be difficult to produce material concerning continuity forests, but age can be an alternative indicator since older forests normally have had time to create more natural values than younger forests. The map layer shows the age division in the forest, which in other words can be an indicator of its biological values.

The basic value for forests was reduced by one point, from two to one, since kNN is a supplementary map layer. Forests that are older than 140 years receive an extra point and get in total 2+1, three points.

The map layer is dated 2005, which implies that there is a source error source since changes such as logging and redistribution of the forest may have occurred since then.

### *Land classification 2011 Map layer from the County Administrative Board.*

The map layer includes lands that have been inventoried in connection with the EU's agricultural support, as well as environmental support with basic and supplementary compensation. Pasturelands and hayfields are also re-

ferred to as claimed land and contain several habitats, for example, forests, limestone plains and beach meadows that are maintained by grazing or hay-making. All land that is claimed receives one or two extra points in accordance with the below.

Habitats in the map layer *Land classifications 2011* that have received another two points and therefore have a total of four (2+2) points are:

- Pasturelands and haylands with special values
- Pasturelands and haylands with special values which do not qualify for single farm payments
- Rock mosaic grazing lands, with the justification that they are often key habitats (Swedish Forest Agency)

Habitats in the map layer *Land classifications 2011* that have received one extra point are:

- Restoration support, with the justification that they are about to be cleared to become pasturelands that are deemed to have high cultural and natural values once completed.
- Limestone plains, with the justification that rocky outcrops have the basic classification 3 and that the lands are kept open longer via the grazing which provides a certain value even if the biological value of the land does not increase significantly due to the grazing.
- Forest pasture, with the justification that forest has a basic classification of 2 and if it is older than 140 years, it will receive another one point. Just as is the case with the limestone plains, grazing does not significantly contribute to an increase in the land's biological value but it prevents the land from overgrowing which represents a certain value.
- Pasturelands or hayfields with general values.
- Pasturelands or hayfields with general values that do not qualify for single farm payments.

Other land classifications that have not been specifically mentioned will not receive any extra points and will retain their basic classification.

### *Wetlands and rich fens. Map layer from the County Administrative Board. 1996 and 2007.*

The map layer includes two inventories, one for wetlands conducted in 1996[71] and a supplementary one for rich fens conducted in 2007[72]. The inventories have been made based on aerial photo interpretations and field visits. With both inventories, a classification from 1-4 was made for the various wetlands and rich fens. The assessment is primarily based on size, the proportion of firm ground and open water, division of elements, geographical position, the height over sea level and the type and degree of encroachment.

Some areas can be found in both inventories. These were identified with the tool Selection by location/intersect. There were overlapping areas and these could therefore be dealt with manually. When duplicates were found, the smaller of the two areas was deleted.

The basic value classification was reduced from four to two for the habitats included. The lands that belong to the two highest classes in the wetland and rich fen inventories receive two extra points and the two lowest classes in the inventory receive one extra point.

### *Water courses. Three map layers consisting of the hl_ layer from Lantmäteriet -the Swedish mapping, cadastral and land registration authority, 2011. A layer of ditching companies in Gotland from the County Administrative Board, 2011 as well as a layer of valuable water courses from the County Administrative Board, 2011.*

Water courses included in the County Administrative Board's layer of valuable water courses received a classification of four or three depending on how unspoilt they were and the prevalence of migratory sea trout. The water courses in the layer of ditching companies as well as some of those in the hl_ layer were assigned to class two as they are seldom completely dry. The remaining water courses found in the hl_ layer were then assigned to class one since they often constituted smaller streams that dry out periodically.

Several of the water courses were indicated in two or more of the map layers which brought about a risk of double classification. In order to identify any duplicates, the tool "selection" was used, but before that, a certain amount of processing of the layers was necessary. The hl_ layer was selected using the tool "share line segment with" and compared with the layer for valuable water courses. It produced few search hits and a manual review was able to be carried out. Identified duplicates were erased from the hl_layer. In the layer for valuable water courses, a classification had already been made

and in order to apply this to the hl_layer, a transfer from the merged layer that contained information from all three layers was performed. ”Selection/identical to” for class 2 and 1 was used in this instance.

Then a comparison between the layer for valuable water courses and the layer for ditching companies was made by using the tool ”selection/share line segment to”. Here too, the number of duplicates was few and a manual review could be carried out, after which the identified duplicates were erased from the layer with ditching companies. Thereafter, the same procedure was carried out for the hl_ layer in comparison with the layer for ditching companies. It gave a larger number of duplicates which meant that a more general deletion process could be carried out. Thereafter, a new run was made to see if there were any further duplicates. This produced a smaller number of duplicates and allowed a manual control and the last remaining duplicates could be erased from the hl_ layer.

Finally, a control was made against the merged layer in order to see if there were any water courses lacking classification. The errors discovered were corrected and all water courses in the hl_ layer were subsequently classified.
The water courses are line objects on the map. In order to use them in the model, they need to be an area. The lines were buffered with 20 metres on each side in order to make an area. Protective zones, the size of which can vary depending on ground conditions, are normally left, but the 20 metre buffering is in line with the guidelines set by the Swedish Forest Agency in connection with the logging of forests which are in close proximity to water courses.[73]

### *Red-listed species, Five map layers (breeding birds, plants and fungi, other vertebrates, insects as well as the observation database) from Species Gateway, Swedish University of Agricultural Sciences.*[74]

The Red List indicates the species that are under threat of disappearing from Sweden. It is based on the internationally adopted criteria from the IUCN, the International Union for Conservation of Nature.[75]

Map layers based on species are considered very much alive as they change in step with the public’s reporting of new finds or when new inventories are conducted. As the source of information shifts from experts to amateur enthusiasts, the scale varies, from an exact description with the aid of GPS to descriptions of an area with no specific details regarding the location of the find. The inventories are also conducted relatively arbitrarily based

| **Code according to the Red List** | **Definition** | **Classification** |
|---|---|---|
| EX, Extinct | A species is *Extinct* when there is no reasonable doubt that the last individual has died. | 0 |
| RE, Regionally Extinct | A species is *Regionally Extinct* when there is no reasonable doubt that the last individual potentially capable of reproduction within the region has died or has disappeared from the region. | 0 |
| CR, Critically Endangered | A species is *Critically Endangered* when the best available evidence indicates that it is facing an extremely high risk of extinction in the wild. | 4 |
| EN, Endangered | A species is *Endangered* when the best available evidence indicates that it is facing a very high risk of extinction in the wild. | 3 |
| VU, Vulnerable | A species is *Vulnerable* when the best available evidence indicates that it is facing a high risk of extinction in the wild. | 2 |
| NT, Near Threatened | A species is *Near Threatened* when it has been evaluated against the criteria but does not qualify for *Critically Endangered*, *Endangered* or *Vulnerable* now, but is close to qualifying for or is likely to qualify for a threatened category in the near future. | 1 |
| DD, Data Deficient | A species is *Data Deficient* when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. | 0 |

*Table 3. The table indicates the Red List codes[76] and what classification each code receives.*

on the people's whereabouts. There are many observations in the proximity of inhabited communities, roads and popular visitor destinations but in more inaccessible countryside they are practically non-existent. This naturally does not mean that there are no species in more remote areas, just not as many observers. It is also possible to see a trend regarding which species are more popular to report than others, this is particularly true in the case of rare birds.

The map layers of the red-listed species contain some very old observations, the oldest of which are from 1755 and some observations also have a very low level of specification, e.g., the location of the find may be described as Gotland, but no more detail than this. In light of this, some information was removed from the included map layers. The observation database is a map layer that was used for the management of find data for the Swedish Species Information Centre before the current system with the Species Gateway was created. A transfer of species is under way but it is not yet complete. The observation database contains several old observations and therefore, the largest removal of items is from this layer. Finds with an accuracy of 11,000 or larger have been removed. Observations made prior to 1979 were also removed. In the map layer for insects, observations registered prior to 1955 with an accuracy of less than 5,000 have been removed. The remaining map layers, Plants and fungi, breeding birds and other vertebrates did not need to be edited before use.

Above is the classification used for the layers included in a table that also explains the red list division based on threat scenario.

The code DD has been assigned to class 0 but as the species in this category may be endangered, it should possibly be a class 1, which can be discussed in future updates of the map layer for red-listed species.

The map layer for red-listed species does not include endangered fish. The result had probably not been affected to any greater degree for Gotland specifically as there is only one species, the European river lamprey, observed in one single location on Gotland, which is included in the Red List. Furthermore, fish are very mobile which makes observations very uncertain. But if the model is to be used in other areas, it may be interesting to include fish as one of the included layers in the map layer for red-listed species.

In several of the map layers for red-listed species, there are very old observations that are not current today (the oldest is from 1755). Some observations are also of such poor accuracy that they provide no useful information whatsoever (e.g. that the species exists on Gotland, but not where, specifically). That is why some objects were removed from the map layers.

The observation database - This is the database used before the Species Gateway. Some of the reported material comes from museums and may be very old findings. Observations dated prior to 1980 have been erased as they were considered too old. Cases where accuracy was 11,000 or larger have been removed as well as those that have an accuracy of around 1,000 where the only location stated is the parish.

Insects - Old observations, prior to 1955 or with an accuracy higher than 5,000 have been erased.

Plants, breeding birds and vertebrates were not edited before use.

***The Archaeological Sites and Monuments database (FMIS). Three map layers from the Swedish National Heritage Board, May 2011.***

We have chosen to use FMIS as a representative for the coast's cultural heritage. The public version of FMIS can be found in Fornsök (www.fornsok.se). The register provides information on all of Sweden's known ancient and cultural historical remains. FMIS is constantly updated with information obtained through inventories and archaeological investigations, which is why regular updating is necessary. As with the red-listed species, more findings are reported in the proximity of inhabited areas, roads and popular visitor destinations since this is where the most development and ground works are conducted.

FMIS is divided into three map layers depending on the physical nature of the remains. A grave is a point, a fence is a line and a settlement is an area, etc. The practice of the Swedish National Heritage Board is that remains of less than 20 metres are registered as a point in FMIS. The FMIS lines have a buffer of five metres on each side so that they become areas which could be used in the model. The buffer size of the lines is based on the County Administrative Council's protective zone used in the preparation of ground for forest plantation.

The FMIS remains have also been classified in five groups, depending on the antiquarian assessment. This assessment is based on the practices of the Swedish National Heritage Board which date back to its archaeolo-

gical inventories which started in the 1930s. The ancient remains categories have constantly increased in number and their statuses have shifted over the years. The Act concerning Ancient Monuments and Finds states that which constitutes an ancient monument. Remains from later time periods can be added to this and, generally speaking, it should be noted that fixed ancient monument are often older. There are no time restrictions is respect of ancient monuments, except for ship wrecks. 100 years must have passed since the boat/ship became a wreck.

The antiquarian assessment is based on various criteria and establishes the value of the remains. However, the County Administrative Councils can establish an assessment other than that stated in FMIS.

| Antiquarian assessment | Classification |
|---|---|
| Ancient monuments and objects yet to be established | 4 |
| Other cultural historical remains | 3 |
| Examined and removed | 2 |
| Information on Geophysical area | 1 |
| Not cultural historical remains | 0 |

*Table 4. Classification of ancient remains*

However, there is a good deal of information that could be used to provide a fairer image. This includes, for example, areas of national interest for cultural heritage management, historic buildings, churches and abandoned churches as well as vicarages. There are approximately 800 sites where abandoned medieval farms have been localized. That they are not included today is due to the same information existing in several of the map layers that need to be examined. Furthermore, there is additional information about find sites for surface finds and places designated as Viking Age ports which has not yet been reported in FMIS. Older and younger map material could be used in the model to analyze, for example, the propagation of the meadows or wetlands.

### *Reclassification of FMIS points and red-listed species*

The remains registered in FMIS as points have been added in squares of 200 x 200 metres along with the red-listed species. Ancient monuments and red-listed species then become diffused and are automatically allocated a protective zone. Thereafter, calculations were made on the number within each square. One of the reasons why the red-listed species received such high points is that there may be several endangered species of lichen on one tree. Another reason is that, for example, breeding birds are reported from year to year in the same location and sometimes on several occasions by several different people. But the largest errors disappear through reclassification.

This was carried out as detailed below:

- A grid was created with the aid of Xtools Pro, Create Fishnet, 200x200 m
- The map layers were divided for the different classifications (select by attribute)
- Spatial join (one to one) is used to calculate the number of points in the squares
- A new column is created and the points are calculated for each square by multiplying the classification with the number of points (field calculator)
- Convert into a raster image
- The total points are calculated for all classes in each square through total cost (spatial analysis/math/plus)
- A reclassification was carried out as some squares indicated very high amounts. So that these would not predominate in relation to other map layers (reclassify)

| Original points for the square | Reclassified point |
|---|---|
| 1-15 | 1 |
| 16-30 | 2 |
| 21-45 | 3 |
| 46 -> | 4 |

*Table 5: Reclassification of ancient remains*

| Original points for the square | Reclassified point |
|---|---|
| 1-50 | 1 |
| 51-100 | 2 |
| 101-150 | 3 |
| 151-> | 4 |

*Table 6: Reclassification of red-listed species*

### *Marine data. Map layer from the Swedish Environmental Protection Agency, 2006.*

There is a lack of good data from which to make assessments of marine environments on a national level. This

primarily applies to vegetation, superficial substrate and depth maps with good resolution. Furthermore, there are no clear national guidelines for the designation of valuable marine environments.

The project to compile and analyse coastal subaquatic environments (SAKU)[77] was commenced in 2005 as an attempt to analyse the potential propagation of some of the more common habitats in shallow underwater environments, based on national geographical information on coasts and seas. Since the project has been conducted on a national level, the resolution is large-scale. The analysis is primarily based on three external factors: depth data, wave exposure and superficial substrate. A table of the collated national data shows the division of the physical factors by county. The table indicate, for example, that Gotland has few environments where the wave exposure is low (protected environments). The environments often have a great value as reproductive and nursery environments for many species of coastal fish. Several of these species suffer from unknown reproductive disorders. We therefore chose to value these environments higher than the other categories for wave exposure.

The categories were classified as follows:

- Ultra-protected, extremely highly protected and highly protected - class 2
- Protected - class 1

Other factors in the map layer were not considered to constitute a basis for valuation within the model. From a national perspective, Gotland is one of the counties that has the most sand bottoms at sea. The bottoms have a high marine value as reproductive areas for several species of flatfish and often contain a rich bottom fauna. In an improved version of the model, these areas would be charted and have a higher classification.

*Image 16. Overview map of Gotland, Kappelshamn. The County Administrative Board of Gotland © Lantmäteriet - the Swedish mapping, cadastral and land registration authority.*

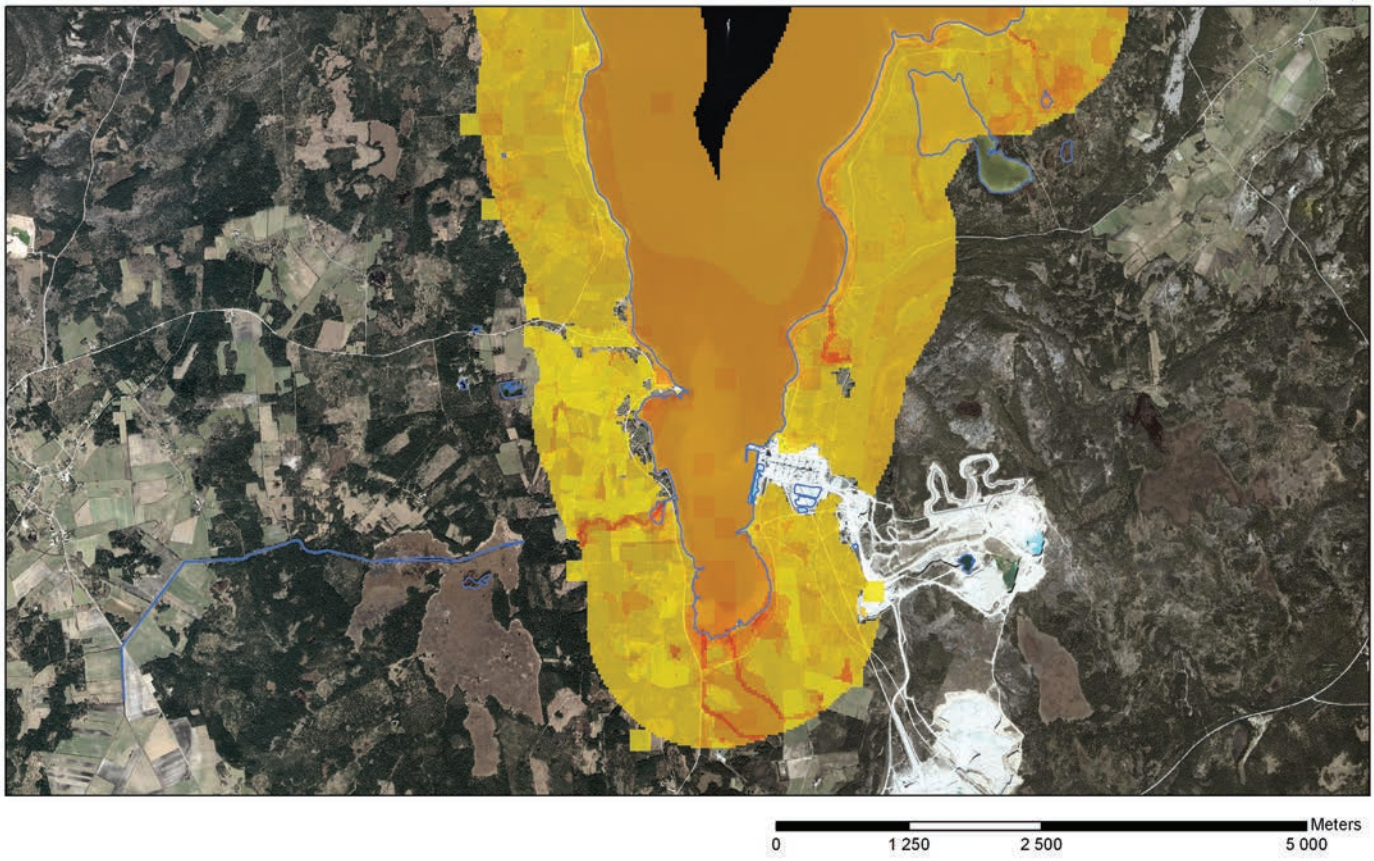



*Image 15. An example of the model with conservation values. The more red the area, the more conservation values there are to be found in one location. The map image shows Kappelshamnsviken in north Gotland. Orthophoto from 2010. In this map image, the additional classification for sea is classified on a scale from 1-4, which is to be corrected to 1 and 2. The County Administrative Board of Gotland © Lantmäteriet - the Swedish mapping, cadastral and land registration authority.*

## 8.4 Map layers for exploitation interests

The map layers over exploitation interests have not been classified. Neither is this necessary as the purpose is to see where the exploitation interests are. These map layers have been used:

- Area of national interest for valuable substances and minerals (SGU, 2005)
- Area of national interest for energy production (the Swedish Energy Agency, 2008)
- Area of national interest for shipping (the Swedish Maritime Administration, 2001)
- Holiday home areas with a 50 metre buffer zone (Statistics Sweden, 2005)
- Densely populated cities and settlements with a buffer zone of 50 metres (Land cover data, Lantmäteriet - the Swedish mapping, cadastral and land registration authority, 2000)
- Ports, industrial and trade units, public services and military facilities (Land cover data, Lantmäteriet - the Swedish mapping, cadastral and land registration authority, 2000)
- Tourist areas in the general plan, Bygg Gotland (General plan, Gotland Municipality 2010)
- Detailed plans (Region Gotland)
- Stone and gravel pits (the County Administrative Board of Gotland, 2011)
- Pier inventory (the County Administrative Board of Gotland, 2011)

Within the Area of national interest for shipping, it is the navigable channels which have been included in the model.

A buffer zone of 50 metres has been added to the map layer Holiday home areas. As far as Holiday home buildings are concerned, only complementary additions to existing buildings can be made along the coast of Gotland, on Östergarn, Storsudret and Fårö. According to a ruling in the Administrative Court of Appeal in Stockholm, an additional building located more than 50 metres from an existing building is not considered to be a complementary addition. Such a buffer zone has also been added in the map layer Densely populated cities and settlements.

Detailed plans have been added to the model for exploitation interests even though certain land is reserved as urban natural areas.

All these map layers have been merged into one where possible, and the various different colours highlight the number of exploitation interests. The bluer the area, the greater number of exploitation interests.

## 8.5 Map layer for protected areas

The protected areas have been collated in a separate model. On Gotland, there are several types of protected areas. These vary in their protection levels and cannot really be compared but we have still chosen to collate them

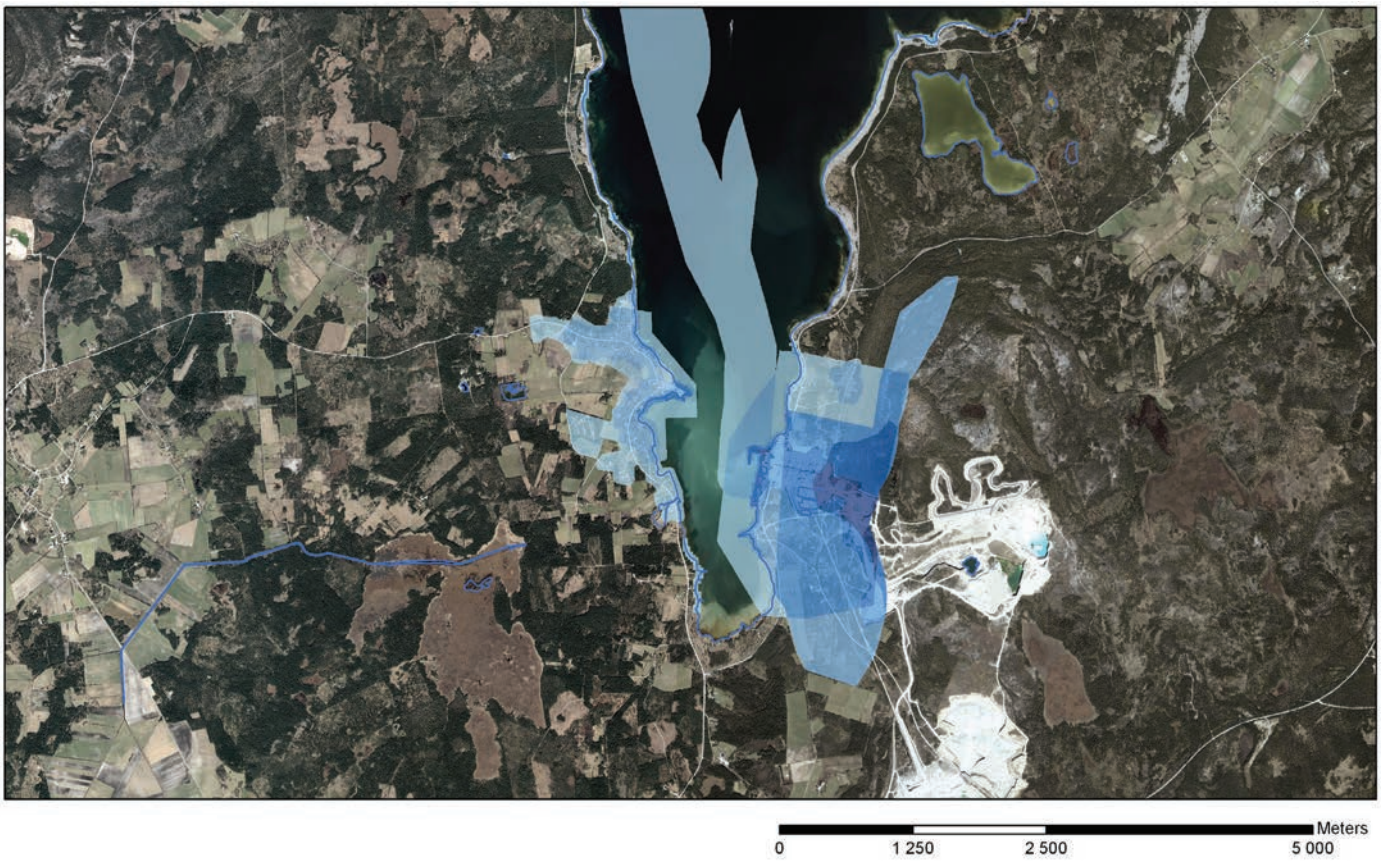



*Image 17. An example of the exploitation model. The bluer the areas, the greater the number of exploitation interests in one location. The map image shows Kappelshamnsviken in north Gotland. Orthophoto from 2010. The County Administrative Board of Gotland © Lantmäteriet - the Swedish mapping, cadastral and land registration authority.*

in a model as all exploitation matters must be examined in more detail in these areas. Furthermore, these areas are well inventoried which produces high values in the model.

In order to avoid double protection, the map layer has been removed if it is equal in area size. For example, Gotska Sandön is a national park but also a Natura 2000 area. Therefore, the national park layer has not been included. The Gotland coast nature reserve includes, by and large, all land within the current coastal protection area. In the model, only the nature reserve has been included and not the coastal protection.

These map layers have been used:

- Animal protection areas (VicNatur, the Swedish Environmental Protection Agency)
- Nature reserves and nature management areas – including the Gotland coast nature reserve (VicNatur, the Swedish Environmental Protection Agency)
- Natura 2000 areas (VicNatur, the Swedish Environmental Protection Agency)
- Habitat protection (the Swedish Forest Agency)
- Water protection area (Region Gotland)
- Culture reserve (the County Administrative Board) – Gotland has one and it is not in the coastal area.
- Nature conservation agreement (the Swedish Forest Agency) – Is not mentioned in the Environmental Code but is a civil law agreement between the Swedish Forest Agency (usually) and the land owner, for a maximum of 50 years.

The starting point for the selection of map layers was Chapter 7 of the Environmental Code, in accordance with Swedish law. Natural monuments are not included because they are point layers and because there are so few objects. It may be possible to include them in a later update of the model. There are other types of areas that have no bearing on a law but where consultation is needed, e.g., key habitats that have not been included in the model.

## 8.6 Update of map layer

In order for the models to be useable, it must be a living system with regular updates. New map layers may also be added. Appendix 1 includes a schedule for the conservation model and all phases executed with the map layers.

Certain selections in the map layers were made before they were added to the model, whilst others were made in the actual model. In some places, ”mask” has been used instead of ”clip”. This was due to the fact that a fair amount of tests were needed before the model could be assembled as a unit. This can be changed to achieve a more standardized model.

Any processing of the map layers can be found under their respective description. The schedule shows that it is rather easy to change propagation area, depending on which question is asked. Appendix 2 includes a schedule for the exploitation model and appendix 3 contains the model for protected areas.

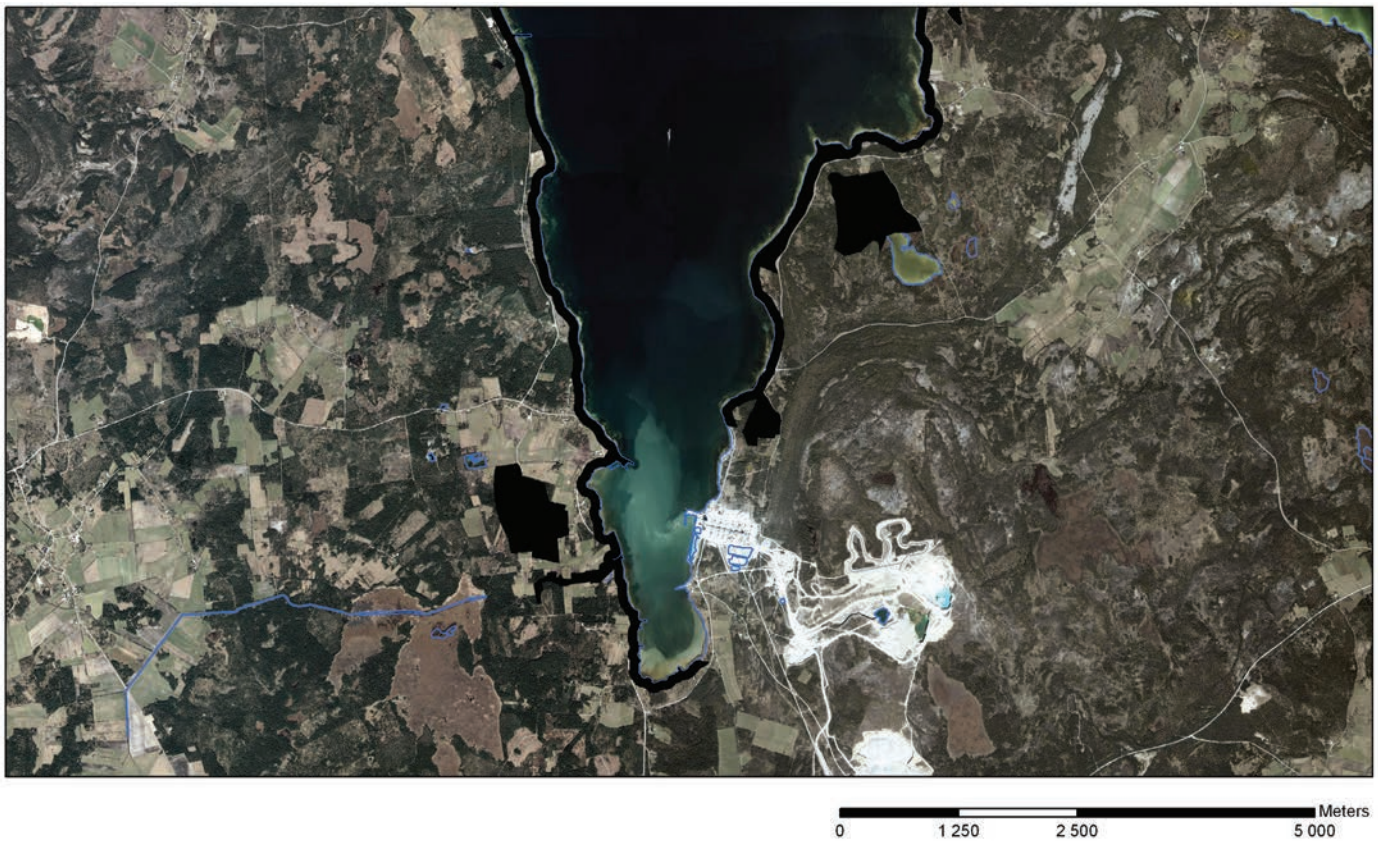



*Image 18. Example of the model Protected areas (black areas). The map image shows Kappelshamnsviken in north Gotland. Orthophoto from 2010. The County Administrative Board of Gotland © Lantmäteriet - the Swedish mapping, cadastral and land registration authority.*

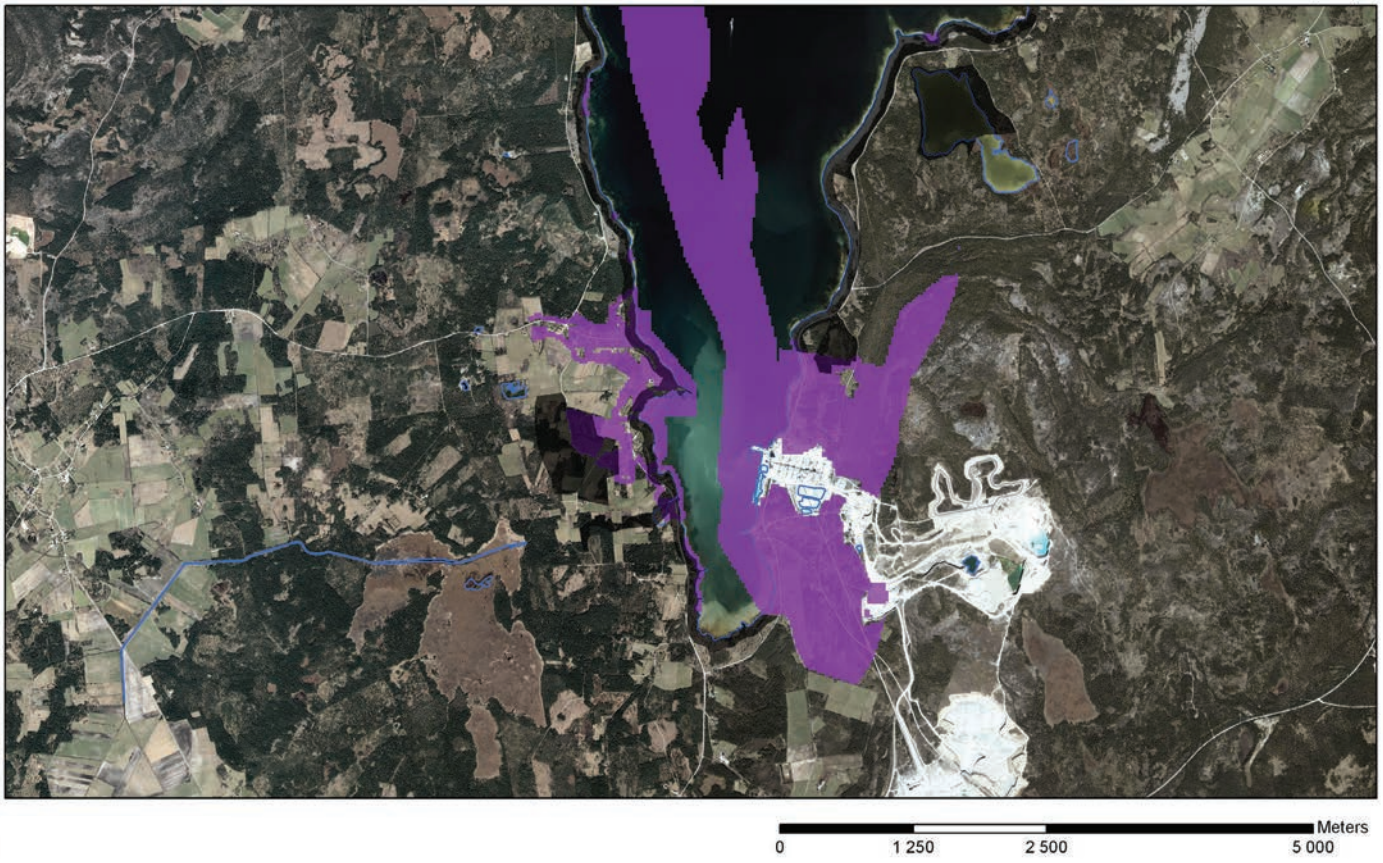
# 9 GIS model with potential for development

The results from the tests of the model in many ways illustrate all the areas of interest and the collisions that may occur between these in a geographical view. The results also indicate where core sites of biological and cultural historical values can be found and therefore where the highest ecosystem services are located. Furthermore, these can form a basis for landscape planning of the areas which will benefit most from protection.

## 9.1 Merger of map layers

In the model with conservation values, the highest value was 14. When combining (classification) the conservation model with the exploitation model it will indicate which areas are potentially in conflict with each other. This model was elaborated upon in order to remove those areas which are protected by law. The map layer for protected areas was used instead. The results can then be further analysed.

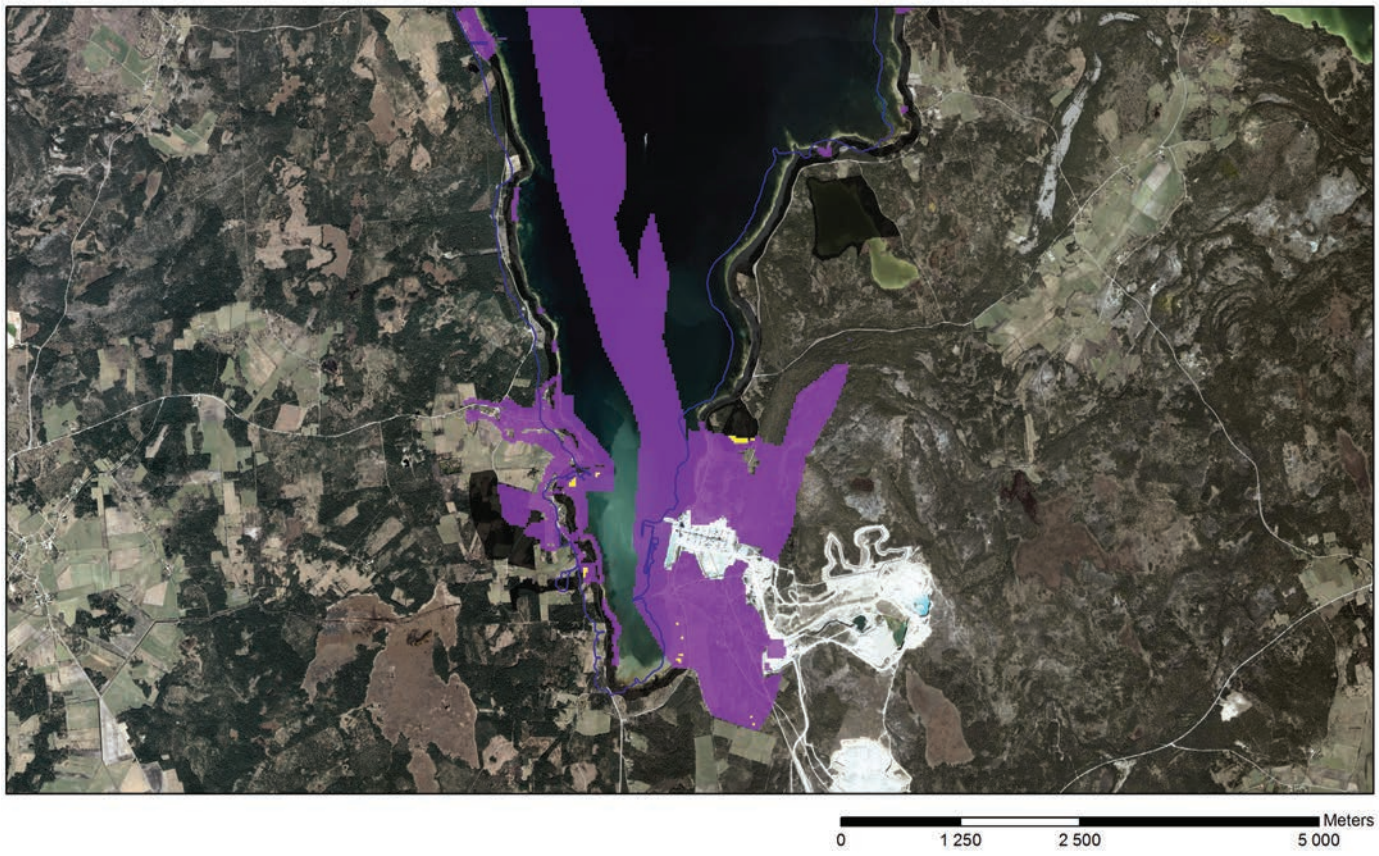
*Image 19. Purple indicates areas where conservation and exploitation clash with each other. Black areas are protected areas where exploitation represents no major threat. Orthophoto from 2010. The County Administrative Board of Gotland © Lantmäteriet - the Swedish mapping, cadastral and land registration authority.*



When combining the conservation model with the exploitation model, it is evident that most clashes occur in or in the proximity of densely populated areas, (cities, small towns and holiday home areas) which corresponds to our expectations. There are three larger areas where there are clashes of interest and these are due to the co-existence of two areas of national interest and a designated tourist area according to the general plan, Bygg Gotland (area of national interest for wind power production, area of national interest for minerals and a tourist area, according to the general plan). Medium- sized clashes that are not near cities, smaller towns or holiday home areas are often areas with detailed plans, areas of national interest for wind power production and smaller ports. These results are also expected, due to the map layers we have used in the exploitation model. Most of the smaller areas of clashes are due to the pier inventory being somewhat unbalanced.

Where the exploitation model clashes with the highest conservation values (8-14 points), it is clear that the habitat has a basic value of 2 or higher, preferably in combination with a wetland or a water course or with high classification, ancient remains or endangered species. The largest area where exploitation interests clash with high conservation values are major parts of Visby, since it is an ancient monument (and World Heritage site) and Visby has a large number of park areas which receive 2 points in the habitats. There are also endangered species and other ancient remains.

*Image 20. The same map as the image above with the addition that the yellow areas indicate where there is a clash between the highest valued conservation values (8-14 points) and exploitation. This is done in order to bring about a smaller workable selection. Orthophoto from 2007. The County Administrative Board of Gotland © Lantmäteriet - the Swedish mapping, cadastral and land registration authority.*



## 9.2 Areas and other facts[78]

***Stretch of coast:***
***Gotland's coastline, including Fårö, is approximately 800 kilometres. The total area of the coastal zone is approximately 123,000 hectares. Gotland's total area is 314,000 hectares.***

**Area**
Of the 123,000 hectares that make up the coastal zone, approximately 60,000 hectares are land. The most common land type is coniferous forest (approximately 20,000 hectares) and thereafter follows pasturelands, (approximately 10,000 hectares). Together, coniferous forests and pasturelands constitute approximately 50 per cent of the total area of the coastal zone.

**Protected areas:**
The protected areas constitute approximately 25 per cent of the coastal zone area. In the protected areas there are 12 animal protection areas, 68 nature reserves, 69 Natura 2000 areas, 39 habitat protections, 11 nature conservation agreements and 14 water protection areas.

**Ancient remains:**
Within the coastal zone, there are nearly 5,000 ancient remains registered, the highest class in the model. On the entire island of Gotland, there are approximately 40,000. In Sweden, there are approximately 400,000 ancient remains. Gotland houses approximately 10% of all of Sweden's ancient remains and the coast of Gotland houses approximately 1.2% of Sweden's ancient remains.

Of the 5,000 ancient remains, approximately 3,000 are ancient monuments. Graves and sword-sharpening stones dominate the point layers, fences and fence systems dominate the line objects and grave-fields dominate the area layers.

Around 1,800 consist of other cultural historical remains, the next highest class in the model.

**Endangered species:**
Just over 17,000 points with endangered species;

210 different species of insects, of which one is in the highest class (CR, Critically Endangered) and 29 of which are in the next highest class (EN, Endangered)

74 different species of breeding birds, of which three are in the highest class (CR, Critically Endangered) and seven are in the next highest class (EN, Endangered)
7 different vertebrates, of which two are in the highest class (CR, Critically Endangered) and one is in the next highest class (EN, Endangered)

324 different species of plants, of which five are in the highest class (CR, Critically Endangered) and 62 are in the next highest class (EN, Endangered)

**Ports:**
Six ports according to the map layer Ground cover data

## 9.3 Estonia and Finland

The GIS model from Gotland was also tested on map layers from other partners within Natureship. Estonia and Finland chose the areas which would be included in the test. In addition, different map layers were chosen. One of the difficulties was understanding the contents of the layers and whether they could be compared as being equal to those from Gotland. Some layers are made up of areas established by EU directives, e.g., Natura 2000 spa (Birds Directive) or Natura 2000 sci (Habitats Directive). Other layers are made up of the areas protected by the country's own law or points. Classification of the layers could therefore not be carried out, except for one in the Estonian model. Instead, each pixel (set at five) received the value 1 or 0, exists or does not exist, for each map layer depending on whether there was an object there. Thereafter, the pixel values were added together and the more objects with conservation values, the redder the pixels become (area).

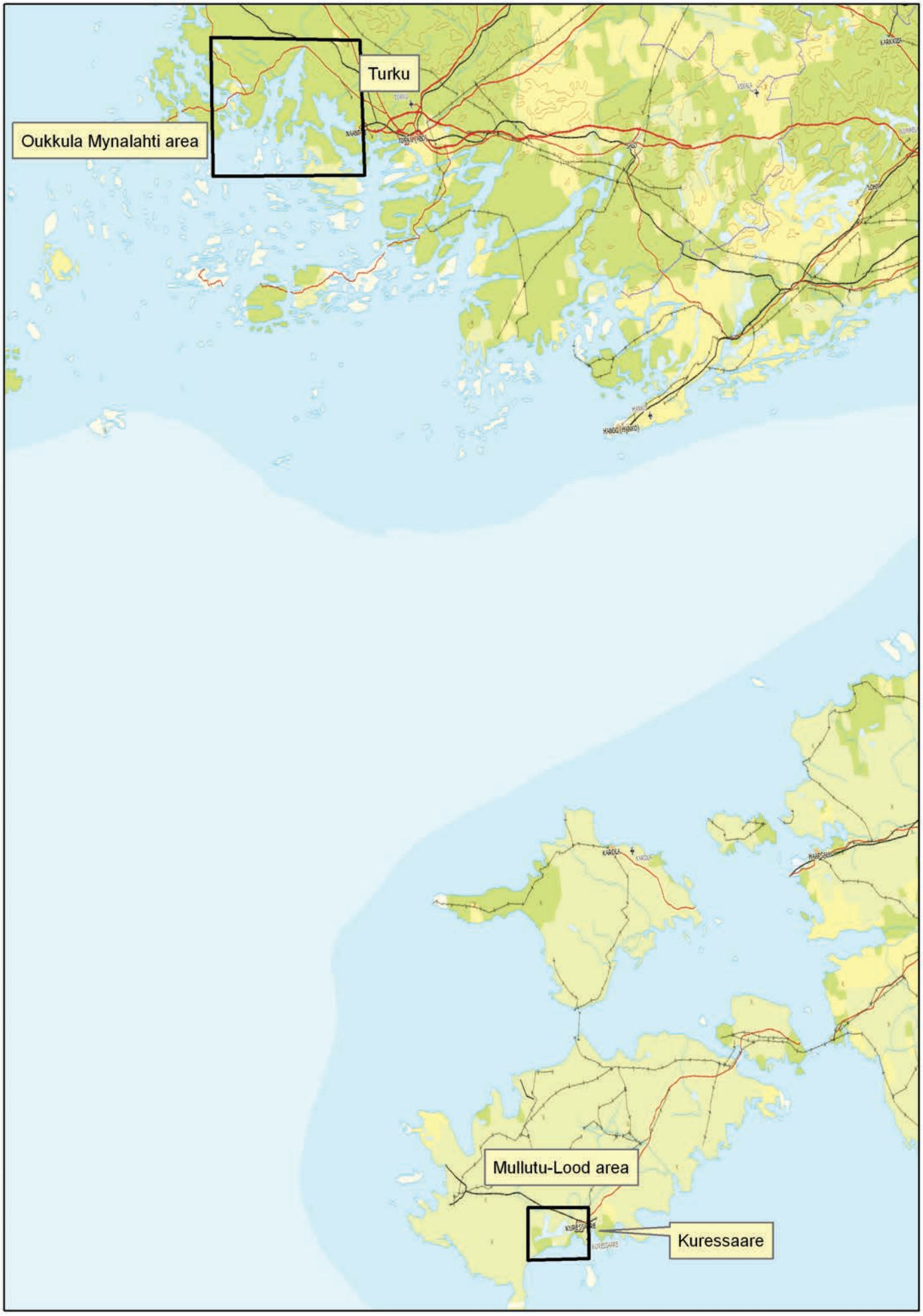



*Image 21. Model areas in Estonia, Mullutu-Lood and in Finland, the Oukkulanlahti area. The County Administrative Board of Gotland © Lantmäteriet - the Swedish mapping, cadastral and land registration authority.*

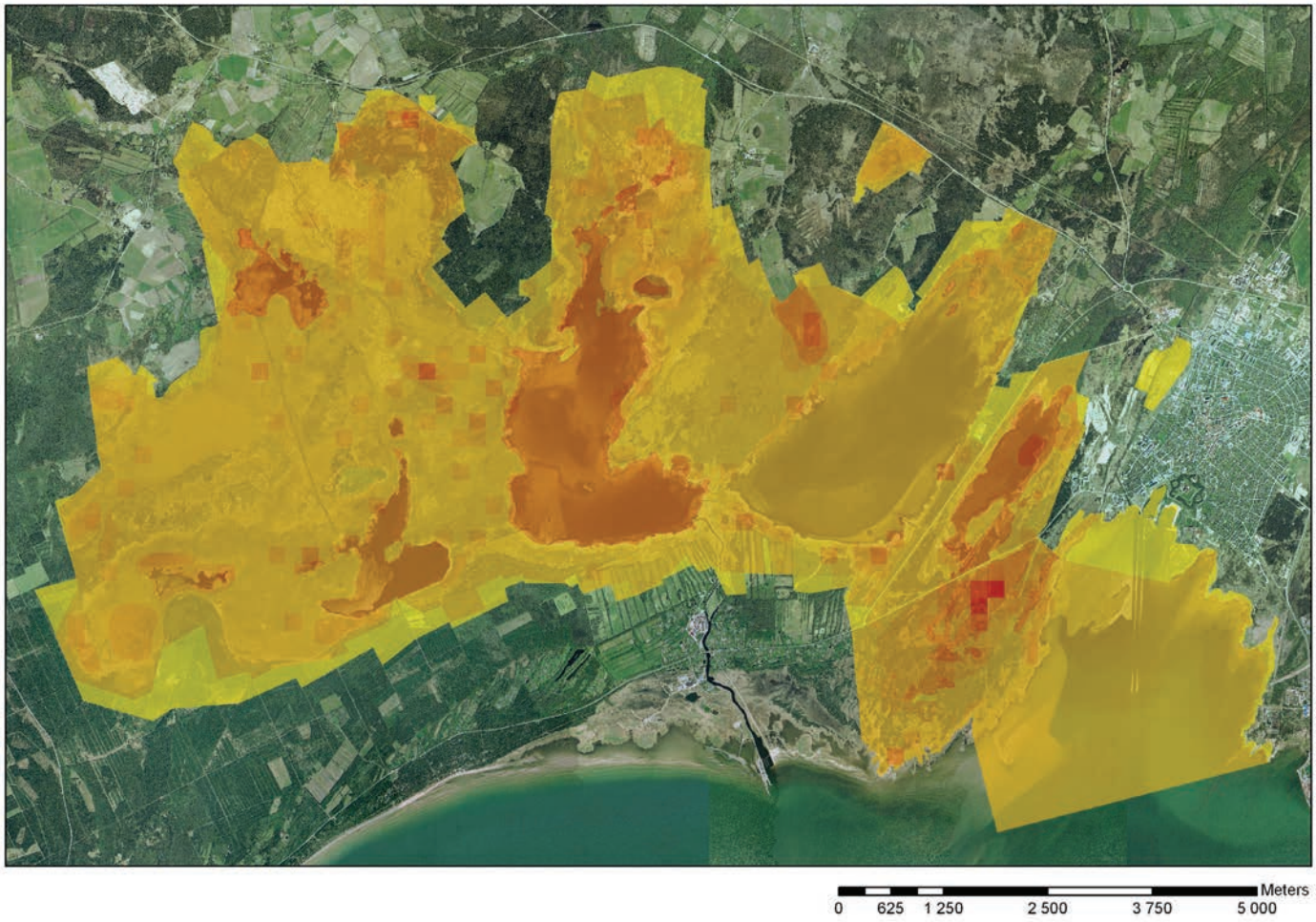
## 9.4 Estonia

Estonia chose a smaller area on Saaremaa (Ösel), just west of Kuressaare, Mullutu-Lood. Here there is a nature management area where a new management plan will be established. The Estonian map layers consist of both conservation values and protected areas. The designations have not been translated to Swedish.

These map layers were included in the model:
Poduste Luha Limited Conservation Area
Natura 2000 spa
Natura 2000 sci
Internationally important bird area (IBA)
Kuressaare Lahe Limited Conservation area
Linnulaht protected area with non renewed protection rules
Loodenina rand protected area with non renewed protection rules
Loode tammik protected area with non renewed protection rules
Mullutu-Lood limited conservation area
Plants III category polygon
Plants II category polygon
Plants III category point
Plants II category point
Animals III category polygon
Animals III category point
Animals II category polygon
Animals II category point
Animals I category point
Fungi lichens I category point

For the species, there was a ready-made classification in three classes. Since the map layers for the species were in point form, it was easy to separate them from the other map layers and subsequently add them to the model. Here, the same system was used as for the points in the model for conservation values on Gotland, see appendix 4.

*Image 22. The map shows the area chosen in Estonia, Mullutu-Lood, west of Kuressaare. The redder the map, the more conservation values exist. The County Administrative Board of Gotland © Maa-amet.*



## 9.5 Finland

Finland chose an area in the archipelago near Turku, the Oukkulanlahti area. The map layer consists of protected areas and conservation values in the form of ancient remains and protected landscapes. However, no classification could be made of the layers. The model therefore did not provide much that was new, except to indicate the location of most of the conservation values and protected areas. The model will however be exchanged for the same model and classifications used on Gotland. The model is described in appendix 5.

These map layers were used:

- Protective zone plans
- Traditional landscapes in SW Finland, old classification
- Traditional landscapes in SW Finland, new classification
- Internationally important bird area (IBA)
- Valuable sceneries in the state level
- Natura 2000
- Nature conservation and wilderness
- Nature conservation program area
- Ancient remains, points
- Ancient remains, polygons
- Constructed cultural heritage 1993, lines
- Constructed cultural heritage 1993, points
- Constructed cultural heritage 1993, polygons
- Constructed cultural heritage areas, which are significant in stat level (RKY), lines
- Constructed cultural heritage areas, which are significant in stat level (RKY), points
- Constructed cultural heritage areas, which are significant in stat level (RKY), polygon

## 9.6 Survey in west Finland

Within the framework for the cross-border project Natureship, an exchange has taken place in Finland between the Centre for Economic Development, Transport and the Environment in the Southwest Finland and the University of Turku. They are the principal partners in the project but are also responsible for two sub-projects ”City meadows” and ”Grazing and water protection”, which aims to develop co-operation and measures within water and nature management in Southwest Finland. Heidi Lampén , a student with connections to the University of Turku and the Centre for Economic Development, Transport and the Environment in the Southwest Finland, has conducted a survey directed at land owners in a specific coastal area. In the survey, the land owners were given the opportunity to highlight the areas and ecosystem services they believed to be the most valuable. Furthermore, they also described how they felt about the spreading of the reeds in the area and what they saw as the consequences of this. The results of the survey are described in an article that can be found in appendix 6.

# 10 Challenges and future possibilities

In order for Gotland's unique coastal region to be planned and managed in a sustainable manner, we need more knowledge than is currently available. Through the project *Integrated coastal zone planning and management in the Baltic region*, current knowledge deficiencies have been localized and suggestions made as to the actions to be taken.

## 10.1 Model, classification and demarcation

The model which has been produced is solid and forms a good foundation for the future identification of ecosystem services. It highlights and evaluates conservation and exploitation interests in the landscape. During the course of the project, several demarcations and revisions needed to be made to the map layers before they were ready for use.

It has also been difficult to provide information regarding social and recreational values in the model. These values constitute the background of a large part of the interests that exist in the coastal zone and they are of great importance to many people who live in or visit the area. The model is designed in such a way that when the material is available, it will be easy to add these values.

It is important to consider that map layers cannot be more detailed or correct than the data which is added to them. Source errors to consider are, for example, the age of the material, the original purpose of the map layer, the inventory method and the scale which has been used. The scale used is significant as it determines how much zoom can be used without the information becoming erroneous. In order to compensate for the lack of correctly detailed map layers of the entire coastal zone of Gotland, a clear aerial photo interpretation was combined with detailed inventories.

Only information about conservation values in the map layers has been classified within the project. The assessments made from these values are entirely based on conditions on Gotland. The classification has been a challenge as a great deal of expert knowledge is required and it is difficult to carry this out in an objective manner.

## 10.2 Development

A possible development in order to be able to include the observer's assessment of the values of the landscape in the model is a land owner survey similar to that carried out by the University of Turku and Centre for Economic Development, Transport and the Environment in the Southwest Finland. In the long-term, the survey could also be used for including social and recreational values in the model. This would provide broader results that would benefit more users. This kind of development of the model would lead to increased usage amongst residents and visitors.

Other ways to include social values in the model would be to use the map layers of the social values of the forest that the Swedish Forest Agency has produced. The sociotope mapping which Region Gotland carries out for some of the island's population centres could also be a good complement. In addition to this, information about, for example, population density, age, sex, work places could also make the model more useable.

The marine part of the coastal zone has so far been difficult to evaluate, there is very little detailed information. This lack of map layers and inventories at sea seems even more acute now as Sweden is investing in physical planning at sea. By combining physical factors such as temperatures, depths, bottoms and data for inventories, test fishing and bottom fauna, nature value maps can be produced. Not entirely different from the maps used in our project.

There are also knowledge gaps to be bridged within cultural heritage management. There is a lack of all-encompassing landscape analyses for the culture values of the coastal zone and inaccurate location data means serious issues for conservation work involving ancient remains. For the future, underlying data needs to be specified and an evaluation of the information carried out.

The exploitation values are not classified within the framework of this project. Supplementary information and evaluation of exploitation interests in the landscape would mean a more all-encompassing model. The utility would increase but it requires more data collection as well as a creation of new GIS layers that are currently missing.

The model can be developed and become even more detailed. A trial with aerial photography inventory was conducted in Östergarn parish on east Gotland, in accordance with the Natura 2000 habitats decided within EU. All nature reserved and Natura 2000 areas on Gotland were previously inventoried in accordance with this system. Through the aerial photography inventory, the spaces between the protected areas were also included, which gave a more complete picture of the landscape. A continuation of the work with covering the entire coastal zone would increase the utility of the model. Classification could also be made for older map material from the 1930s in order to realize landscape analysis around areas, overgrowth, the spread of species etc.

## 10.3 Use

The model is meant to be a guidance to administrators on regional as well as local levels who e.g., work with social planning or matters regarding building permits. In the long-term, more authorities and public functions e.g., the rescue services may find it beneficial to quickly find out were great conservation values are located e.g., when fighting forest fires. The public too can find benefit in a model that can be used as a diorama e.g., via a web portal. There, information can simply be given about where in the landscape the biological or cultural historical values exist.

It is however important to remember that a map layer provides a snapshot image and can never constitute the absolute truth. It is required of the serious user to gain in-depth knowledge about the matter in question.

A planning tool like our model is in demand, not just in Sweden but also in other European countries. The testing of the model in Estonia and Finland led to varied results since the information could not be transferred freely between the countries. Although, if the material and the digital systems can be made more compatible between countries, there is a great potential for development and possibilities for good results also outside Sweden.

## 10.4 Continued work

In addition to a better knowledge base, there are three key questions to answer before the public planning and management of the coastal zone can be implemented in a sustainable manner.

Firstly, there is a need for continued dialogue and acceptance among those residing and working in the area. Transparency, dialogue and development in mutual understanding are keywords. The landscape of Gotland has been farmed during a very long period of time and it can sometimes be difficult to make Gotlanders accept decisions made by authorities. National objectives and adjustment may sometimes be experienced as unfair by the individual. In order to create sustainable decisions in the long term, better anchoring on a local level is necessary. A dialogue between authorities, residents, operators and exploiters in the coastal zone will be crucial in the future.

Secondly, a proper comparison between reality and the model is needed in order for it to be credible. In addition to the conservation values, experience values need to be added to the model. An area that is considered worthy of protection and valuable according to Natura 2000 may be experiences as uninteresting from the perspective of the observer.

Financing is the third key questions, who is paying for the knowledge bases? An example is contract archaeology where the Act concerning Ancient Monuments and Finds states that the exploiter is liable for costs in connection with interference with an ancient remain. The matter of financing is crucial for when the continued work with the model can commence.

One way of developing the model could be to include it in the Swedish Local Nature Conservation Programme (LONA) run by Regions Gotland called Naturvärdeskarta (Natural value map). One of the objectives is that the user, by a simple click on the map, shall receive information about a selected area, regarding what laws apply and what consultation need to be conducted. There are ongoing discussions as to whether the LONA project could use and develop out basic model. This should be in the interest of the County Administrative Board and Region Gotland as both planning and building permit administrators are part of the target group.

Finally, it can be concluded that even though much work remains before we can achieve a sustainable usage of the coastal zone, the project has made great progress towards the goal. The developed model can be a functional tool in the future work with physical planning in the coastal zone. It is also flexible. If only data and resource capacity is available, it is possible to develop the model to include much more information and areas than that accounted for within the framework of the project. It can be seen as a valuable foundation to build on in the effort to obtain sustainable planning and management of the coast of Gotland, and in the long-term, many other coastal areas too.

# 11 Foot note list

1. The County Administrative Board of Gotland. 1993.
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78. The figures, except for those regarding the coastal zone, have been taken from Gotland i siffror 2011 (Gotland in figures 2011), published by Region Gotland.

# 12 Glossary

## Chapter 1

| | |
|---|---|
| *GIS* | Geographic Information System |
| *Interreg* | Territorial Cooperation Programme |

## Chapter 2

| | |
|---|---|
| *Ecosystem services* | Natural resources and processes produced by the ecosystems, e.g., bioenergy and water purification. |
| *Territorial waters* | The part of a State's territorial sea that is outside the baselines that demarcates the State's inner waters. |
| *UNESCO* | The United Nations Educational, Scientific and Cultural Organization. |
| *World Heritage Site* | Sites of great cultural significance and geographic areas of outstanding universal value. Elected in accordance with the World Heritage Convention. |
| *Ancient monument* | In accordance with the Act concerning Ancient Monuments and Finds; remains of human activities during ancient times. They shall have come into existence through ancient customs and be permanently abandoned. |
| *Natura 2000* | Network within the EU for the protection and conservation of biodiversity. |
| *Sedimentary rocks* | Species of rock that are formed at the surface of the ground. For example limestone, sandstone and slate. |
| *The Silurian Period* | Era approximately 444 – 416 million years ago. |
| *Community association* | A community association is a land or fishing area that is shared by several properties and managed jointly by the properties that have a share in it. |

## Chapter 3

| | |
|---|---|
| *Cross-Sectional Work* | Work that is conducted over operational borders between different operators but towards a common goal. |
| *Resilience* | The long-term ability of a system to cope with change and to develop further. |
| *Biodiversity* | A measurement of how many living organisms exist. |

## Chapter 4

| | |
|---|---|
| *Landing* | Landing place for boats, cleared from stones. Often limited by rows of stones on the long sides. |
| *Hill fort* | Fortified construction from prehistoric times and the Middle Ages. |
| *Fortificatory construction* | Fortification |
| *Drying stand* | Remains after construction for drying fishing-nets. |
| *Fenced in land* | The part of farm grounds located nearest to the farm, dwellings, arable land and meadows. |
| *Light pole* | Ancient lighthouse. Is comprised of a fire bucket attached to a pole. |
| *Posts for seine fishing* | Fixed fishing tool. Comprised of a cleared area on the beach for laying down nets that were then tightened when the fish was within the seine. |
| *Stone ship* | Type of grave. Erected on Gotland during the Bronze Age. |
| *”Skåre”* | Protection that has been used to hide when hunting; primarily birds or seal. |
| *”Släke”* | Gotlandic word for seaweed that was used as fertiliser. |
| *”Vårdkase”* | Stacked piles of timber, wood or brushwood that could be lit in order to e.g., warn of approching enemies. |

## Chapter 5

| | |
|---|---|
| *”Klintstup”* | Detached rock wall. |
| *Shingles* | Smaller rocks that have been polished and rounded through friction against each other on lake or sea beaches. |
| *Abiotic* | Non-living part of the ecosystem. |
| *Photic zone* | Other name for the Euphotic zone, which is the top water layer in a lake or a sea that receives light and in which photosynthesis takes place. |
| *Habitat* | An environment where a certain species of plant or animal can live. |
| *Primary production* | The process within which organic substances are produced from non-organic substances of living creatures. |
| *Secondary production* | The biomass produced by primary consumers, e.g., growth or dairy production. |
| *Nutrient salt* | Crustal solids, also called minerals that nourish living organisms. |
| *Invasive alien species* | Species that have been introduced to areas outside of their original habitat. |

| | |
|---|---|
| *Vascular plant* | Plants that are characterised by adaptation to live on land through well-developed transport systems for water in stems and leaves via special vessels. |
| *Rauk (Stack)* | Stone pillars on Gotland and Öland, primarily on beaches. |
| *Coastal protection* | The Swedish coastal protection legislation can be found in the Swedish Environmental Code. The purpose of coastal protection is to secure public access to coastal areas. Coastal protection shall also preserve good living conditions for animal and plant life on land and in water. |

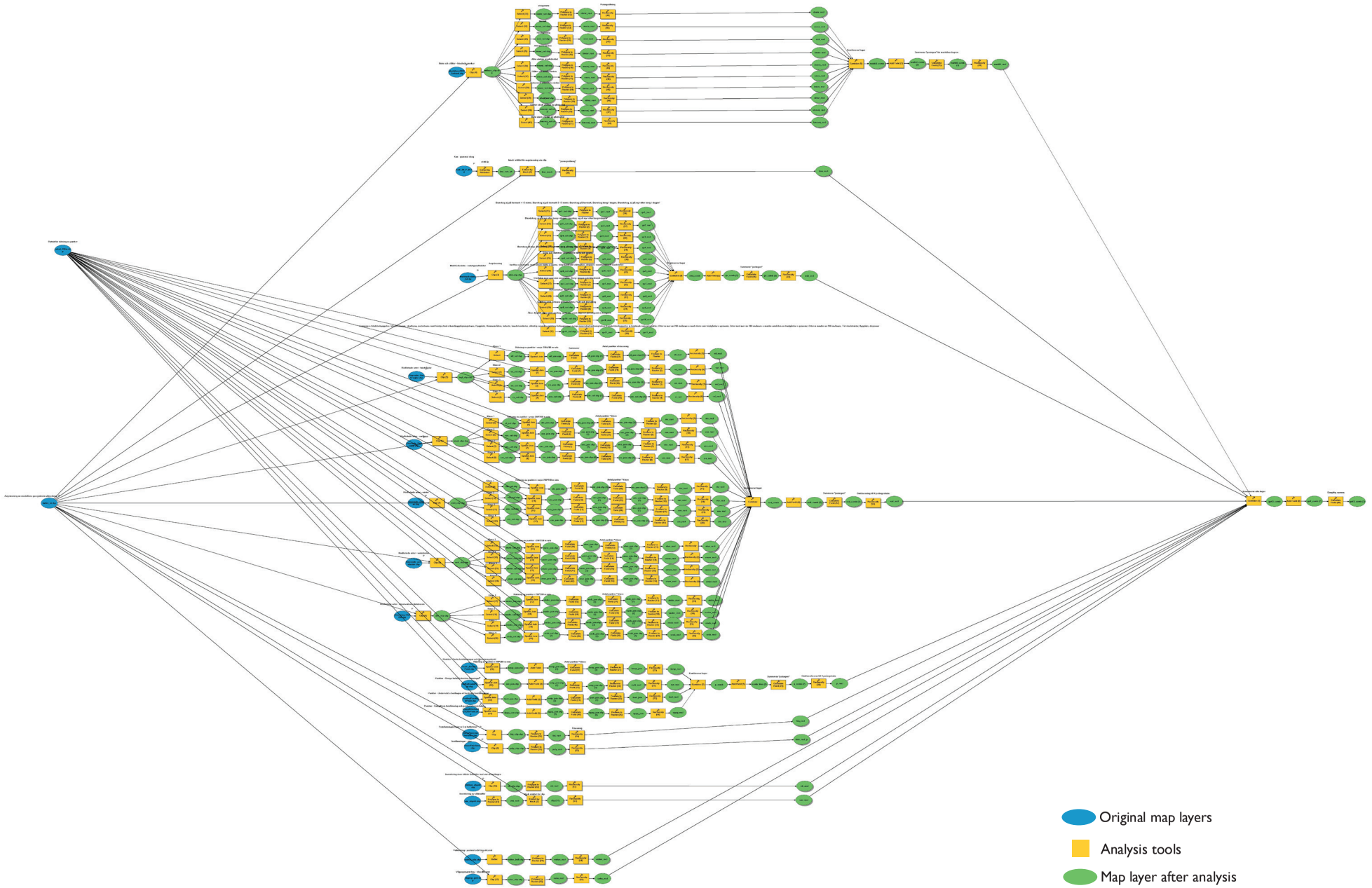
## Chapter 6

| | |
|---|---|
| *General plan* | A municipality wide plan that accounts for the main outlines of the intended use of land and water areas and the future developments in building. |
| *Historic building* | Building or construction that is protected in accordance with the Act concerning Ancient Monuments and Finds. |

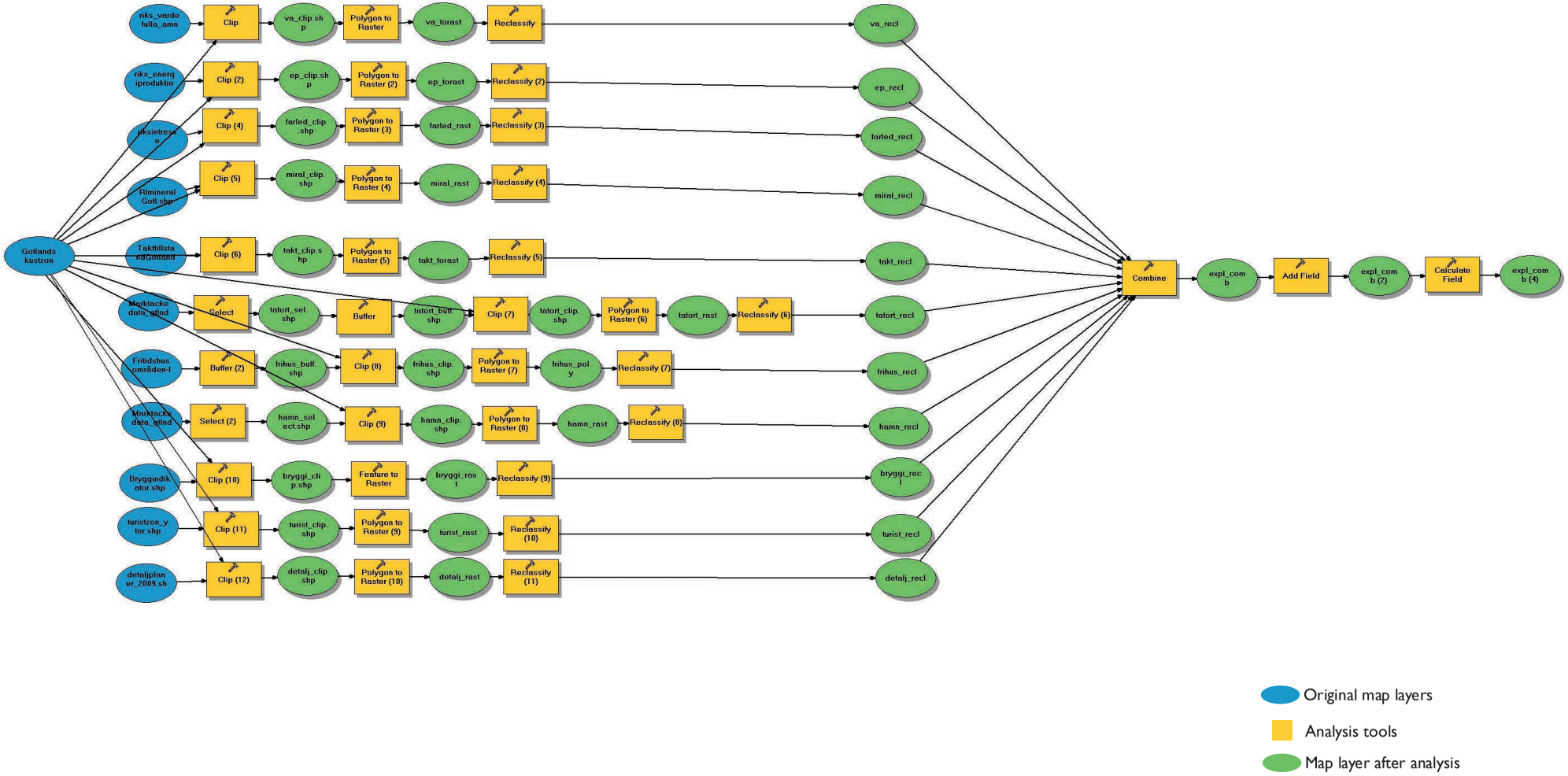
## *Chapter 8*

| | |
|---|---|
| *Key habitat* | Key habitats are forest areas with very high natural values. These areas have qualities that mean that they are important for the survival of endangered or disadvantaged species in the forest. |
| *Area of national interest* | Area of national interest is a term that may relate to an area, a place or individual objects that are protected and considered important from a national point of view. |
| *Hayfield* | Meadow where the cutting of high grass is performed with a scythe or knife mower. The grass is dried into hay as animal feed for the winter. |
| *Diffusing* | To diffuse. The coordinates for species and ancient remains are not indicated with exactness, they become diffused as it is only indicated that they exist in a square 200x200 m, but it is not known exactly where. |
| *Vector layer* | Vector files are constructed with points, lines or polygons. Vectors are stored as x and y coordinates. |
| *Raster layer* | Raster files are used in general to store image information, built on pixels. |

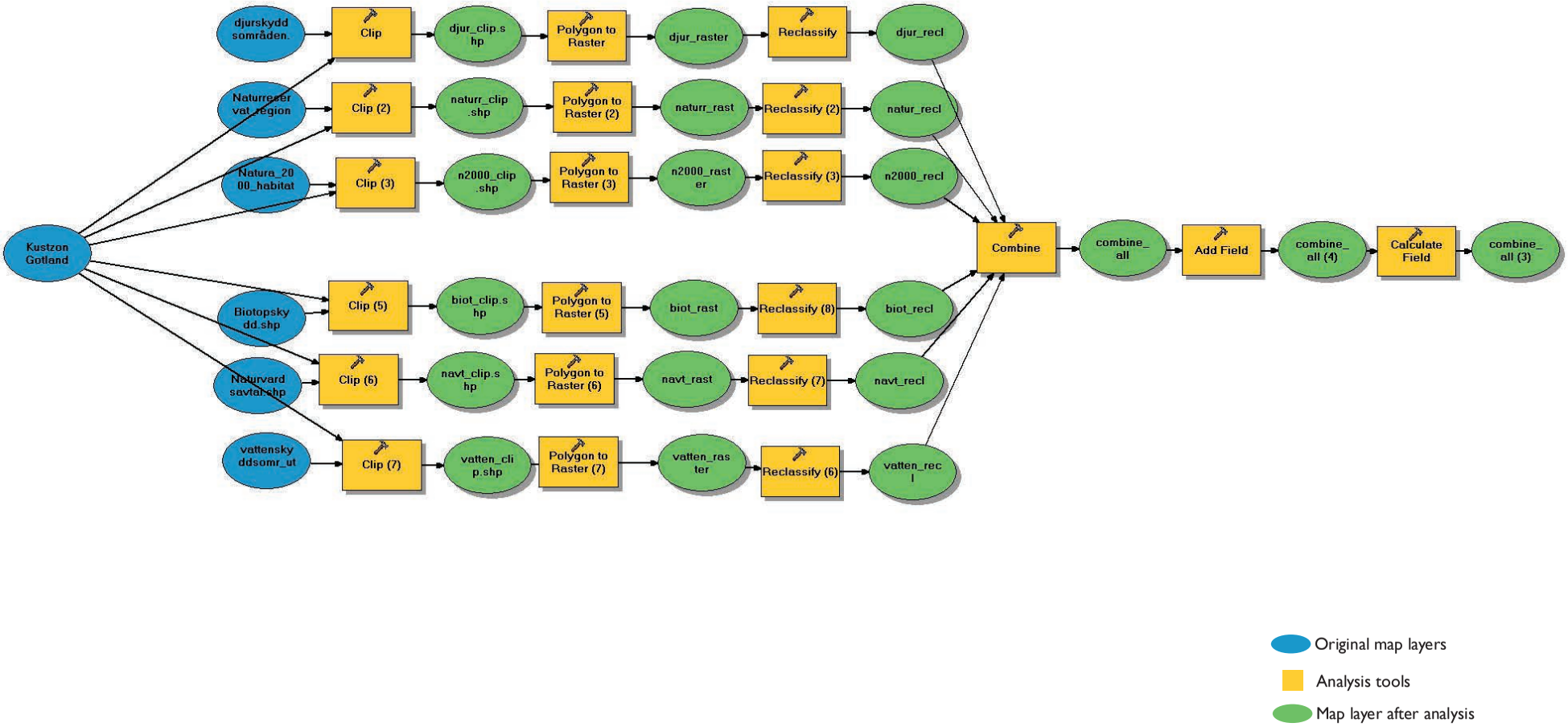
# 13 Appendices



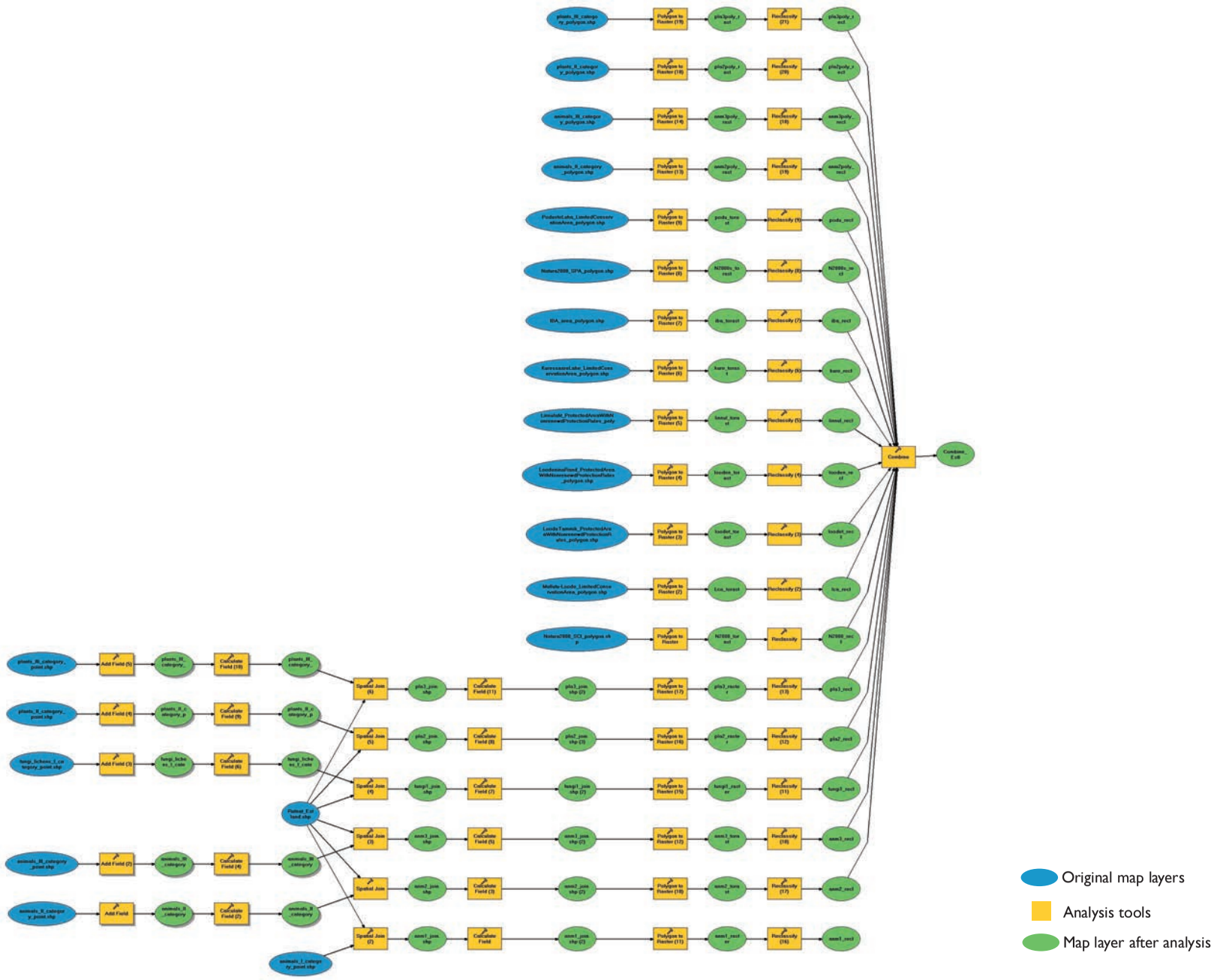

Appendix 1. The model of ecosystem services on Gotland



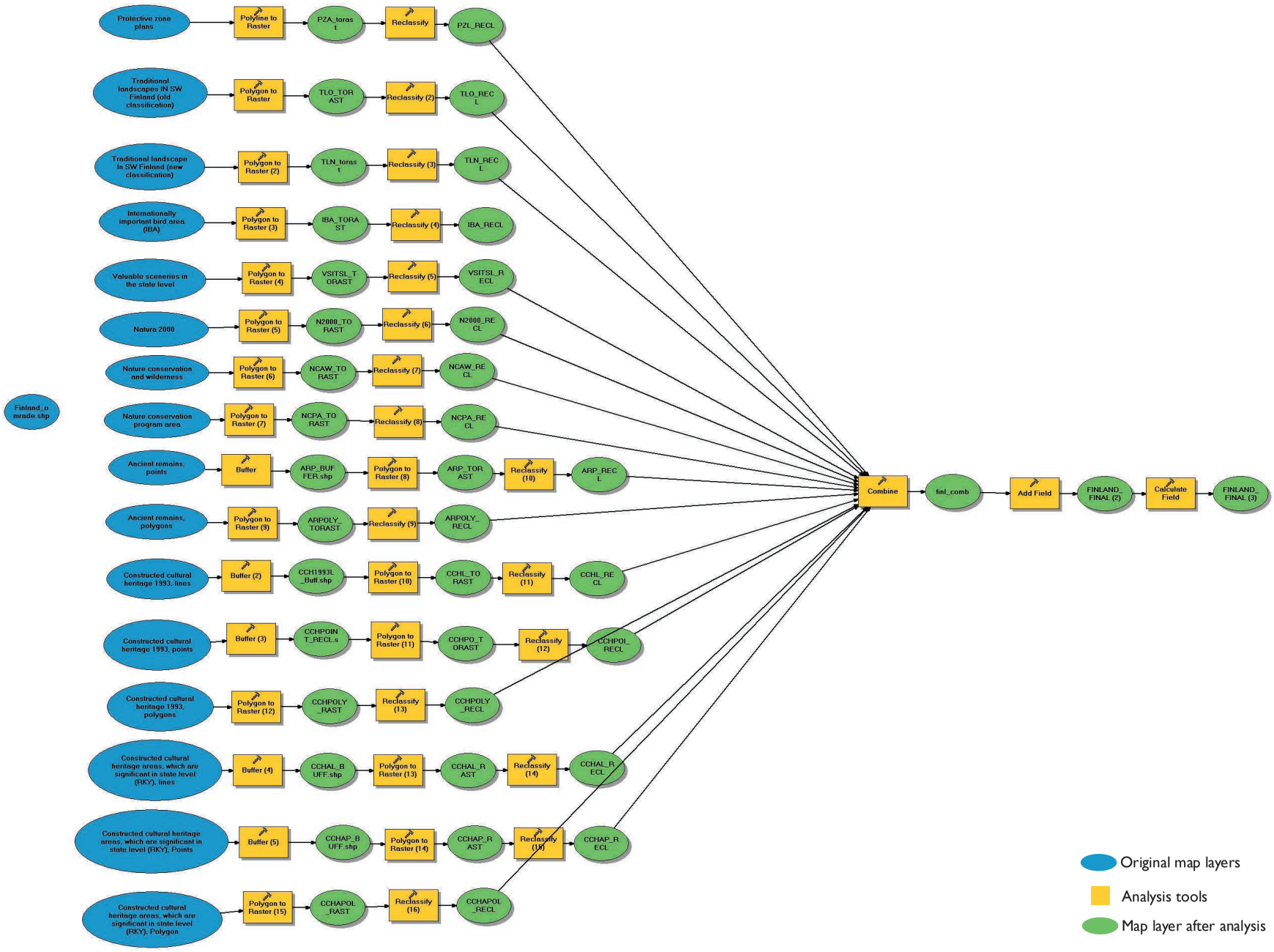

Appendix 2. The model of exploitation on Gotland




Appendix 3. The model of protected areas on Gotland




Appendix 4. Model of the map layer of Estonia




Appendix 5. Model of the map layer of Finland

# Bilaga 6. Mapping ecosystem services using a participatory approach: A case study from Southwestern Finland.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## Introduction

The eutrophication of water areas and the substantial declining in grazing of the coastal meadows has led to the overgrowth of coastal areas and increase in the size of reed beds (Ikonen and Hagelberg, eds., 2007). In consequence, the number of bird and plant species has decreased. In addition, the recreational value of many areas has declined as people are having for example trouble in swimming and fishing. To deal with this issue, Centre for Economic Development, Transport and the Environment of Southwest Finland has started a three-year long water and nature management project called VELHO. One part of the project highlights the importance of coastal planning and is developing a new planning method, which combines the objectives of natural resources utilization, conservation of biodiversity, protection of waters, recreational use and landscape management (Coastal planning, 2011). To proceed in reaching the objective of multiple-use planning, an optimal network of harvested reed beds and coastal meadows is being designed in the project for areas where reed beds are growing heavily.
The aim of the study is to support the coastal planning process in the Oukkulanlahti - Naantalinaukko area in Finland by questioning the landowners how they currently use the area and how they wish to develop the area in the future. One of the most important goals is to find out how the landowners in different parts of the planning area respond to the overgrowth caused by reed beds. More precisely, the aim is to find out how they respond to the negative effects of the overgrowth and to the possible further utilization of the reeds.

The study area Oukkulanlahti - Naantalinaukko is situated in Southwestern Finland in the municipalities of Masku and Naantali (Figure 1). The area of about 5500 hectares consists of a large sea bay and its coastal areas, where beds of the Common Reed (Phragmites australis) grow in many parts strongly. Most of the land and water properties in the area are privately owned but there are also some state owned properties as well as some undivided water shares (Aalto, 2007). The northern parts of the study area are included in the Oukkulanlahti Natura 2000 network of protected areas and designated as Special Protection Areas (SPAs) under the EU Bird Directive (Cooperation on bird wetlands, 2010).

*Figure 1. Location of the study area in Southwestern Finland.*

The planning area was delimited taking into account aspects of water management, biodiversity and landscape management. Only the residential buildings, which were located right next to the water area, were taken as part of the planning area. Based on the delimitation of the study area, address data to reach all owners of land and water properties in the area was ordered from the National Land Survey of Finland. The survey questions and the analysis were planned in order to answer the following research questions.

1. What kind of ecosystem services do the landowners identify in the study area?
2. What kind of management preferences do the landowners have for the study area?
3. How are the ecosystem services and management preferences divided spatially in the area?

The classification of the different ecosystem services in the area were adapted from and based on the study by Hein, van Koppen, de Groot and van Ierland (2006, pp. 212). Their classification suited the best the purposes of this study and it seemed reliable as they had used important ecosystem classifications as a basis (Ehrlich and Ehrlich, 1981; Costanza, et al., 1997; De Groot, Wilson and Boumans, 2002; Millennium Ecosystem Assessment, 2003) when making their classification. As the questionnaire was sent to landowners of all age and educational background, questions were made only about cultural services (Table 1) and a few production services to keep the questions as clear as possible.

*Table 1. The cultural ecosystem services from the questionnaire*

| Cultural ecosystem services |
|---|
| Provision of opportunities for recreation and tourism |
| Provision of attractive landscape features enhancing housing and living conditions |
| Provision of scientific and educational information |
| Provision of cultural, historical and religious heritage |
| Nature and biodiversity (provision of a habitat for wild plant and animal species) |

*Table 2. Threats to ecosystem services from the questionnaire*

| Threats to ecosystem services |
|---|
| Factor that troubles or disables movement / traffic |
| Noisy area |
| Littered area |
| Smelly area |
| Decline of environmental value caused by overgrowth |

Negative values can often be seen to be related to threats or degrading processes that are functioning on certain ecosystem services (Raymond, et al., 2009). Therefore, the respondents were also asked to evaluate the areas negative cultural ecosystem services, which can be considered as threats to other ecosystem services (Table 2). It was considered important for the planning work to research the threats and to give them spatial locations using participatory mapping when questioning the landowners. The location of the conflict areas where positive and negative values or opposite management preferences are located in the same area, are crucial to find out. Additionally, the management preferences for the questionnaire were planned to match the aims of integrated planning of coastal areas. However, the emphasis was on the possible reed bed cutting in the future (Table 3).

*Table 3. Management preferences*

| Management preferences for the future in the study area |
|---|
| Reed bed should be cut away permanently |
| Reed bed should be cut yearly during the growing period |
| Reed bed should be cut yearly during the winter |
| Reed bed should be left growing in its present way |
| The area should be restored as a coastal meadow and grazed or mowed with regularity |
| The area should be restored as a wetland |
| The landscape should be opened by clearing the trees and bushes |

# Material and methods

## *Planning the questionnaire*

A methodology for analyzing different landscape values spatially has been developed during the recent years (Brown, 2005; Alessa, Kliskey & Brown, 2008). These types of landscape values include for example aesthetic, cultural, biodiversity, recreation, economic, historic and wilderness values. The methodology has been found to have spatial coincidence between the mapped local values and science-based priority areas used for management in recent studies (Raymond, et al., 2009). Therefore, the same type of methodology was used in and adapted to this study.

The questions and structure of the questionnaire were planned in co-operation with related projects, especially with the Finnish Environmental Institute, where there was a similar study in the area of the Gulf of Finland at approximately the same time of this study. A test group of persons with different background and age was used to improve the clarity of the questions. Finally, the mail survey with five different sections was sent to 877 landowners. The first section dealt with the landowner's ownership and relationship to the area. The values and different ways to use the area were queried in the second part, which was also quite important for the identification of the different cultural and production ecosystem services as well as the threats to these services. Subsequently, aspects of the history of reeds in the area were asked in the third section. The fourth part dealt with the current state of the area and the need of management, which was considered crucial background information for the planning work in the area. Lastly, in the fifth part, the respondents were asked to provide some basic background information.

Landowners were asked to identify the locations of landscape values and management preferences on a colored survey map of the size of A3. The map was indexed in a grid, which had letters from A to T horizontally and numbers from 1 to 20 vertically. In the map questions the landowners were asked to choose one or more of the indexed rectangles and write the code of that location in the questionnaire. This method was used in order to provide the landowners the opportunity to use the same location on the map in several questions. If they had drawn the answers on the map, the same location could have only been used once to keep the answers clear enough for the analysis.

## *Hot Spot Analysis*

Recent studies have found the identification of hotspots a practical way to be able to integrate multiple values in management of certain area to be able to prioritise the management efforts (Chan, et al., 2006; Raymond, et al., 2009). Therefore, in this study, in order to find out whether there are areas with clustered values, for example cultural ecosystem services or threats, the Hot Spot Analysis tool, which uses the ArcGIS 9.3.1 Getis-Ord Gi* statistical method, was used. With the Hot Spot Analysis tool, it is possible to see whether the clusters seen on the map are statistically significant and therefore worth to be investigated further (Hot Spot Analysis – Part 1, 2011). To be precise, the tool is testing if there are clusters of high values and clusters of low values in the data set. In this case the tool is testing if there are hotspots of polygons with certain ecosystem services or management preferences, which have high rates of the certain service or preference, which are surrounded by high rates of the same service or preference. The tool also tests if there are low rates surrounded by low rates. The important decision, which has to be made when using the Hot Spot Analysis tool, is to choose the right Conceptualization of Spatial Relationships. The idea is that there is an interaction between a feature and its neighbours. In this case Zone of indifference was chosen for the best alternative of the different Conceptualizations of Spatial Relationships. It uses a critical distance to decide, which neighbours it will include in the analysis. After the critical distance is exceeded, it uses inversed distance to weight the features.

The general rule for choosing the critical distance is to be sure that the distance chosen insures that all the features have at least eight neighbours (Hot Spot Analysis (Getis-Ord Gi*), 2009). If a too small of a distance band is chosen, some of the features will not have enough neighbours or any neighbours, which could mean that the results may not be valid. In this case, the Global Morans I statistics tool for spatial autocorrelation was used to find the best critical distance band for the analysis. It calculates a Z score for the entire study area. The Z score is a measure of how clustered the values are. There is a different Z score for each different distance band chosen. The analysis was started with a distance of 500 meters, which is the smallest scale still interesting for the study as the grid rectangles were 500 meters times 720 meters in size. The tool was run 26 times, in 500 meter intervals, up until 3000 meters, which was picked as a cut-off point. After that distance the boundaries of the study area were reached even from the very central parts of the area. The same Global Moran I spatial autocorrelation analysis was

run for different management preferences and landscape values in order to find a common critical distance that could be used for the different hot spot analysis. It was important to find a common distance band to be able to compare the results of the different analysis as separated layers on the same map.

The Z scores were illustrated in graphs, which showed the global Z score values in 26 different distance bands. The Z score values that decrease with distance are the most interesting points in the graph because there the spatial autocorrelation is not as strong any longer, so the critical distance could be chosen to be at the peak value. For this study 1000 meters was chosen as the distance band because that was approximately the average value of the different autocorrelation tests run for the values and management preferences. It was also a distance that was quite easy for people to picture. So the critical distance, which is measured for the hot spot analysis is a 1000 meters radius from the centroid point of each rectangle.

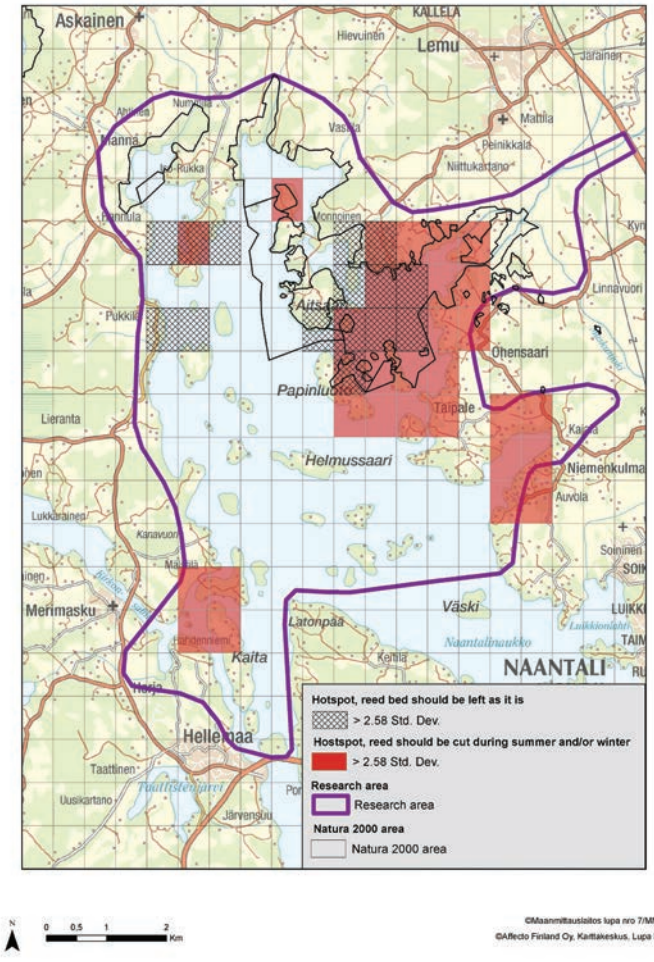
# Results

## *Characterization of the respondents*

The total response rate for the survey was 30,9 % as a total of 271 landowners returned the questionnaire. A great amount, 218 respondents, answered that they owned a vacation home in the area. Much smaller amount, 36 respondents, lived permanently in the planning area. Most of the respondents who owned a vacation home in the area spent there 3-6 months (92 respondents, 34 %) or 1-3 months (84 respondents, 31 %). Only 20 respondents (7 %) spent over 6 months yearly at their vacation home in the area.

## *Results of the hot spot analysis*

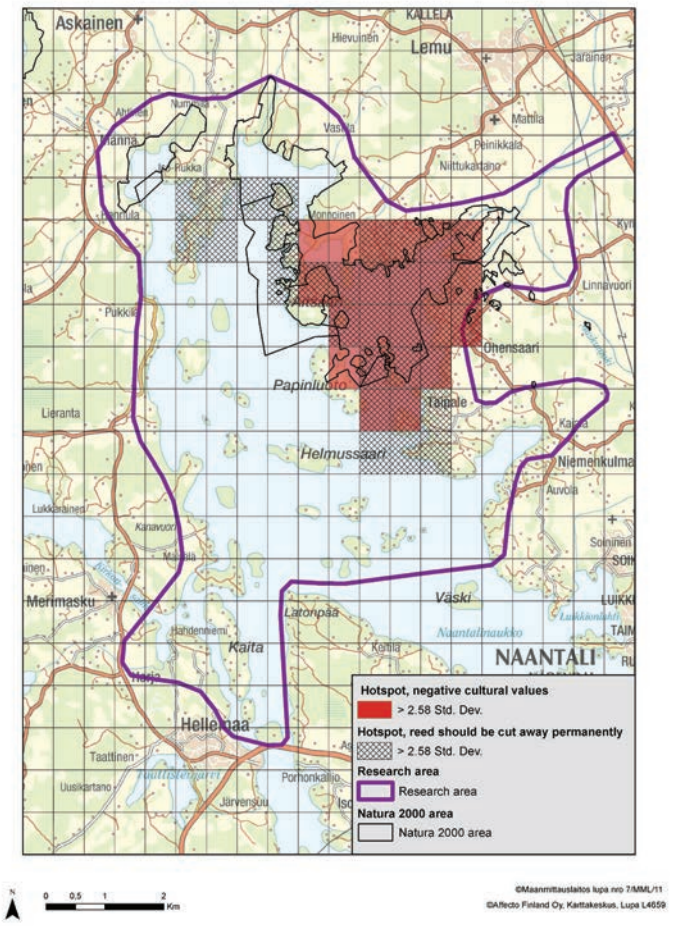
*Figure 2. Combination of hot spot maps of a) areas where the reeds should be cut during summer and/or winter, and b) hot spot map of areas where the reed bed should ne left as it is.*




Hot spot analysis was used as a tool to find out whether the cultural ecosystem values, threats and the management preferences were clustered spatially in some certain locations on the map. The analysis was started with the management preferences for the area as they were considered most interesting and critical background information for the planning work. The aim was to find out whether the opposite management preferences were located in the same area forming places of possible conflicting opinions or if they were in completely different areas spatially. When comparing the hot spot map of the nearly opposite management preferences of ”reed bed should be left as it is” and ”reeds should be cut during summer and/or winter”, the hot spots were placed on top of each other in a total of eight rectangles in the northern parts of the study area (Figure 2). One of these areas of possible conflicting interests is in the northeastern part, in the bay of Halkkoaukko, which is the mouth of the river

Hirvijoki. Another, a bit smaller area of possible conflicting interests is situated in the northwester part of the area between the bays of Rukanaukko and Oukkulanlahti.

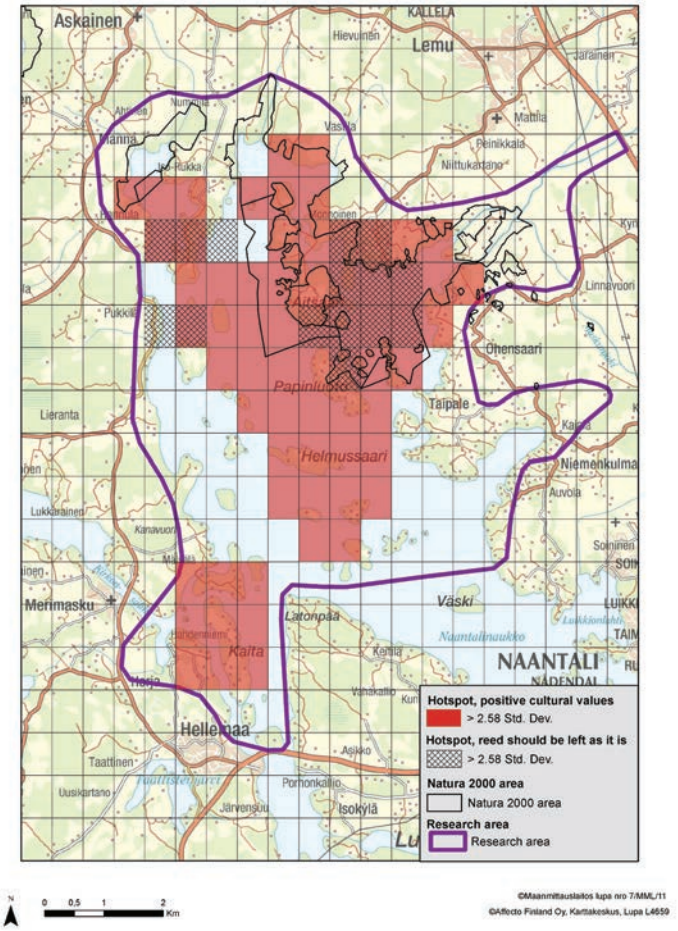
*Figure 3. Combination of hot spot maps of a) threats (negative cultural values) and of b) areas where reeds should be cut away permanently.*




In the following analysis the combination of the hot spot maps of the threats and of the management preference ”reeds should be cut away permanently” were compared on top of each other (Figure 3). The two clusters that appeared in the hot spot analysis are located almost exactly above each other when the map layers are overlaid. Both of the clusters are located again in the northern part of the study area with an emphasis on the Halkkoaukko bay in the northeastern corner of the area.

In the third analysis the hot spot map of all positive cultural values was overlaid with the hot spot map of the management preference ”reed bed should be left as it is” (Figure 4). The values of cultural ecosystem services formed two separate clusters in the hot spot analysis. The larger cluster is located in the central and northern part of the study area while the smaller cluster is located in the southern part of the study area, in Merimasku. The hot spot analysis of the management preference ”reed bed should be left as it is” formed three individual clusters, which are all in the northern part of the study area. The hot spots of the two analyses are placed on top of each other in a total of 13 rectangles in the northern and central parts of the study area.

*Figure 4. Combination of hot spot maps of a) positive cultural ecosystem values and of b) areas where reed bed should be left as it is.*




## Discussion

Even though the alternatives of threats that the respondents could choose from did not focus purposely on the problem of overgrowth caused by reed beds as there were a variety of different kinds of negative cultural values to choose from, the clusters formed in the hot spot analysis are situated almost completely overlapped with the cluster formed in the hot spot analysis of the management preference ”reeds should be cut away permanently”. Therefore, it seems that the northeastern part of the study area is seen to be a place where both the threats and the interest to cut the reeds away are concentrated.

However, many positive cultural values that might reflect some degree of contentment with the area are located in the same northeastern corner of the study area. In addition, the management preference of “reed bed should be left as it is” was also located in the same area causing some even stronger signs of possible conflicting interests in the area. For the purpose of planning the management of the area, the location of each value and management preference should be analyzed more precisely. One important factor is also the existence of the Natura 2000 area in the northern part of the study area where many of the possible conflicting interests are situated. The process of forming the Natura 2000 area might have triggered the conflicting interests in the area and the Natura 2000 factor should therefore be carefully considered in the planning.

The problem with collecting information for management using participatory geographical information is the level of accuracy of the results. One has to keep in mind when analyzing the results that the respondents may not necessarily see the area in the same way as the researcher who might have been in the area for only a short time but who has been researching the area from various sources and maps. Additionally, it is not always completely clear how the respondent has understood the question. However, the participatory mapping is still an important tool in order to get a spatial location for values that are based on experiences and are therefore valuable for planning the management of an area.

It would be interesting to send the same questionnaire to the landowners during some other season of the year than summer, to find out whether some certain seasonal trends affect the type of respondents and the answers in general. The problem of the overgrowth caused by reed beds might be unnecessarily highlighted during the summer. The clusters of management preferences, ecosystem service values and threats could possibly have spatial shifts during different time of the year as the number of habitants and the size of reed beds vary during different seasons. The prioritizing of the management resources should be done keeping in mind as holistic picture of the area as possible.

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# INTEGRATED COASTAL ZONE PLANNING AND MANAGEMENT IN THE BALTIC REGION

## A GIS-model developed in Gotland

The coastal zone is the bearer of a great number of values and efficient physical planning in necessary in order for future generations to be able to enjoy these. GIS data, such as that produced within the project Integrated coastal zone planning and management in the Baltic region, forms an important part of that work.

The project has been conducted within the framework of the interreg project Natureship where Sweden as well as Finland and Estonia have participated. By using existing map data, a GIS model have been developed, that illustrates conservation values and exploitation interests in the coastal zone and the clashes between them. The model may also in the long-term come to function as an informative tool for the public, by indicating values for recreation, exploitation and conservation within the area.

The results of the project form an important basis for coastal zone planning with great potential for future development and the possibility to provide an even more all-encompassing base for physical planning in other areas as well.

Länsstyrelsen
GOTLANDS LÄN

CENTRAL BALTIC
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