

## Land cover types and ecological conditions of the Estonian coast

Ehrlich, Üllas<sup>1\*</sup>; Krusberg, Peep<sup>1,2</sup> & Habicht, Kalju<sup>1</sup>

<sup>1</sup>*Estonian Institute of Economics at Tallinn Technical University, 7 Estonia ave., 10143 Tallinn, Estonia;*

<sup>2</sup>*E-mail peep.krusberg@maaamet.ee; \*Corresponding author; Fax +3706998851; E-mail yllase@tami.ee*

**Abstract.** Detailed analysis of the land cover of the Estonian coastal zone is presented based on Estonian laws on coastal zone management, the CORINE Land Cover (CLC) system, the status of protected areas, and administrative division data of Estonia. By law the coastal zone is defined as a 200-m wide zone landward from the mean sea level line. The length of the Estonian coastline (including the islands) is 3794 km. The 200-m zone of the Estonian coast is very diverse. Out of the 34 CORINE land cover types represented in Estonia 30 are found in the coastal zone. Three dominating land cover types in the coastal zone of Estonia are inland marshes, coniferous forest and semi-natural grassland. Their total share is 47%; the other 27 land cover types represented here cover 53% of the coastal zone. The Estonian coastal zone is generally in a good natural condition. The proportion of artificial surfaces throughout the zone is merely 4.7%, while agricultural landscapes cover only ca. 10%. Land cover data for the coastal zone are also presented by county. Of the 200-m coastal zone 24% is under protection, which is more than twice the value for Estonia as a whole (11%). Legislative protection of the coastal zone is presently satisfactory. The use of the CORINE Land Cover system enables comparisons with other European regions since CLC data have been compiled for most of Europe.

**Keywords:** Coastal zone; CORINE Land Cover; Geo Information System; Nature protection; Protected area; Remote sensing.

**Abbreviation:** CLC = CORINE Land Cover.

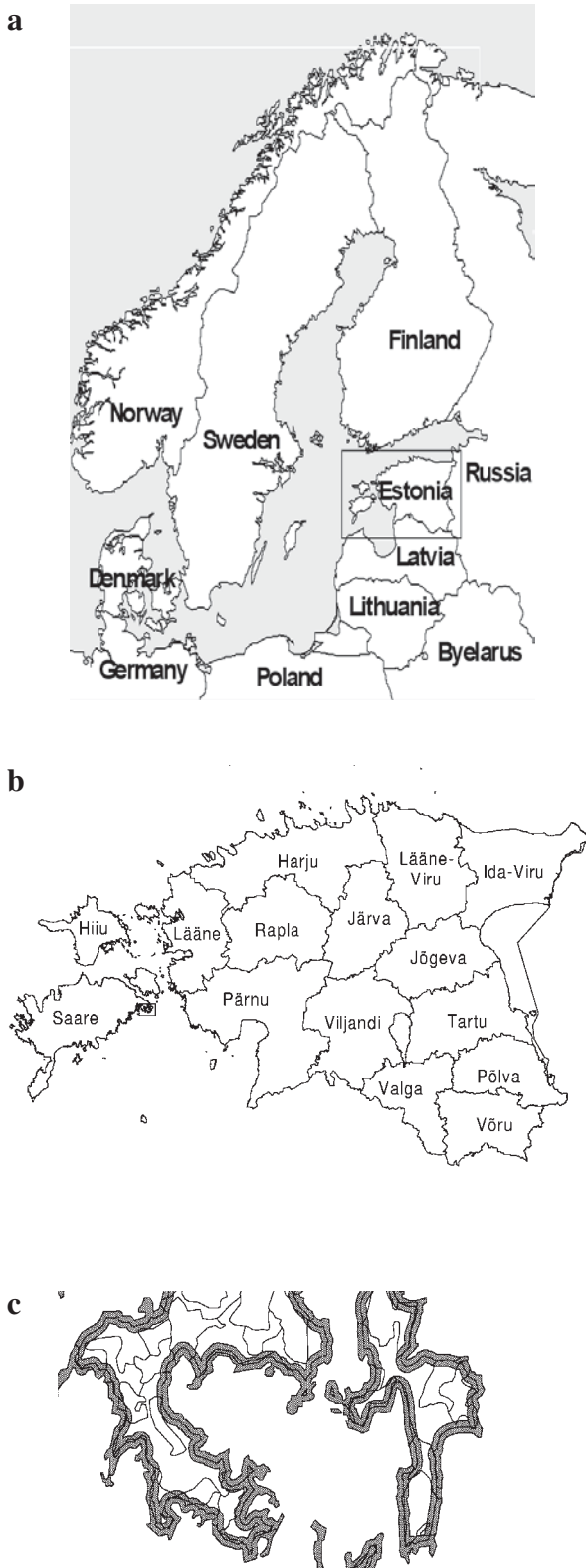
### Introduction

The length of the Estonian coastline is 3794 km, of which 1242 km is mainland and 2552 km insular (Fig. 1). In Estonia, the crystalline bedrock consists of Vendian, Cambrian, Ordovician, Silurian and Devonian sedimentary rocks. On the coast the following rocks crop out: in north Estonia Cambrian and Ordovician clays, sandstone and limestone; on west Estonian islands Silurian limestones and in southwest Estonia Devonian sandstone (Martin et al. 1998). As the earth crust rises continuously (1-2 mm per year) many coastal formations are situated inland from the contemporary coastline. Notably, large old dunes are found, now covered with forest which are no longer under maritime influence.

The Estonian coast is naturally very varied due to its geological diversity, the gradual uplift of the earth crust and transformations caused by ice. The coastal types usually occur as mosaics reflecting the different sediments and formation processes. Traditional human land use forms such as grazing and the construction of infrastructure add to this effect.

Estonia's long and indented coastline makes it an important area for migratory birds along the East Atlantic Flyway. Estonia has many coastal wetlands, such as shallow bays and coastal meadows, and the continuous annual land rise of up to 2 mm creates many habitats suitable for waterfowl (Martin et al. 1998). Ca. 3 million migrating birds rest in the Estonian coastal zone during spring and autumn migration (Lilleleht 1995). The Estonian coast also provides a relatively favourable habitat for grey seals (Martin et al. 1998).

For historical reasons the Estonian coast is more natural and relatively little influenced by human activities compared to many other European countries. The administrative division of Estonia reflects the natural differences between regions. In connection with the transition to a market economy, a very strong development of the coastal zone, supported by both domestic and international capital, has become noticeable in recent years. Its influence on the coastline is often negative, regarding the aesthetic value of the coast,



**Fig. 1.** Location of the study area. **a.** N. Europe; **b.** Estonia and its administrative division; **c.** Coastal detail with the 200-m coastal zone indicated in black.

biological diversity and other natural values. The Estonian Marine and Freshwater Coasts, Shores and Banks Act defines the coast as a 200-m wide zone landward from the mean sea level line. The law stipulates various restrictions on economic activity and utilization of resources in this zone with the purpose of protecting the coastline, e.g. erection of new buildings not economically connected to the coast, clear cutting of woods, etc. The authors have composed an original database and have analysed the land cover in the whole 200-m wide coastal zone based on the CORINE Land Cover (CLC; Coordination of Information on the Environment) system. This CLC program provides qualitative and quantitative land cover data which are consistent and comparable across the whole of Europe (Anon. 2000). The CLC nomenclature is presented in App. 1.

## Methods

### *Database compilation for the 200-m coastal zone structure analysis*

The database was compiled using the following existing and publicly available data sources:

- CORINE Land Cover database;
- Estonian administrative division database;
- Estonian nature protection areas database.

All these databases (layers) are built up using geographic Information System (GIS) principles, i.e. in this case all three data layers include area-type (polygon) data and with every polygon certain descriptive (attribute) data are stored. Data processing was done using GIS software ArcInfo (Environmental Systems Research Institute, Inc.). After these layers were logically united, the result included 'elementary' polygons each having attributes defining land cover type, administrative unit, protection zone type, etc. In order to obtain data for the coastal zone, buffer polygons were generated along the coastline and added to the resulting database using union operation.

The CORINE Land Cover database for Estonia, being part of European Union's CORINE program, was completed in 1996-1998 (Anon. 1999). The concept of land cover is relatively new and sometimes confused with land use but is becoming more popular, especially in relation to the development of remote sensing. To map the biophysical cover of the Earth's surface, land cover reflects the nature of natural (e.g. forest, water body, bare rock, etc.) or man-made (e.g. built-up area, road, etc.) features. In contrast land use is concerned with socio-economic functions (e.g. agriculture, protection, etc.). For determining the current state of the environment, a cartographic inventory of land cover is used.

**Table 1.** Estonian adaptation of the CORINE LC 100 classification scheme: modifications of definitions and appended subclasses.

Code	Land cover class	Definition
<b>Forest and semi-natural areas</b>		
3.2.2.	Alvar grasslands, moors and heathlands	Vegetation with low and closed cover, dominated by shrubs and herbaceous plants (juniper, heath, briars, etc.) and sparse pine stands, which represent alvar grasslands, moors and heathlands.
3.2.4.1.	Transitional woodland/scrub on mineral land	Areas planted with spruce, pine or other tree species in abandoned lands, sandy plains etc. Clear-cuts occur inside forests; they can be new or regenerated (h > 1.3 m). This class accommodates also pastures, grasslands and abandoned fields overgrown with scrub.
<b>Wetlands</b>		
4.1.1.1.	Inland marshes	Marsh vegetation adjacent to the sea, rivers or lakes are composed of reeds, bulrushes and other water plants.

The CLC database is compiled using common principles for the whole of Europe:

- a working scale 1:100000;
- use of data from Landsat MSS/TM satellite images;
- smallest units mapped are 25 ha with a minimum width of 100 m;
- land cover nomenclature hierarchically structured in three levels with a total of 44 classes.

The CLC database reflects the state of the land cover at the time Landsat images were taken (09.07.1994, 27.07.1994 and 24.08.1995). Land Cover mapping focuses on the appearance of landscapes rather than their genesis and nature, e.g. according to the original definition wetlands as a land cover type occupy less than 5% of the Estonian area but actually it is known that ca. 20% of Estonia is peat-covered (Anon. 1999). Due to these peculiarities of the Estonian natural environment, some alterations and amendments to the standard class definitions (third level), as well as a few new national classes (fourth level; Table 1) were introduced.

The administrative division database is compiled by the Estonian Land Board, which is responsible for geodetic, cartographic and cadastral works in Estonia. Administrative boundaries are kept in different nominal scales (1:10000, 1:50000 and 1:250000); for the project 1:50000 scale data were chosen because they fit the CLC data best.

The nature protection area database is managed by the Estonian Environment Information Centre; boundaries conforming to the 1:10000 scale. To harmonize the scale of protection areas boundaries with other databases some generalizations were made before joining these databases.

Due to the different scales and sources of initial data, boundaries of the same features in different databases are usually not identical. For example, the coastline in CLC (interpreted from satellite images) and in

the administrative layer (taken from cadastral measurements) may differ several km as far as reed bed areas are concerned. When such databases are joined, the result will have many small slivered polygons along the boundaries which are common for two or more input layers. To eliminate these polygons, considerable database cleaning is needed using relatively high cleaning tolerances and manual editing. The coastal zone is especially vulnerable in this respect because both CLC and the administrative databases include parts of the coastline; moreover there are parts of nature protection areas with boundaries along the coastline. The authors estimate that the errors of the analysis connected to these overlaps are ca. 5%

## Results

### *Land cover types in the 200-m coastal zone according to CORINE*

The results of the analysis of the CORINE 200-m zone land cover types for Estonia are presented in Table 2. The land unit with the largest area in the zone is inland marshes (4.1.1.1) with ca. 7900 ha, accounting for 16.6% of the zone area. Beaches tend to be overgrown with reeds during recent decades, which is due to the decrease in mowing and grazing. As everywhere else in Estonia (Anon. 1996; Kukk & Kull 1997), the area of semi-natural grasslands has diminished greatly in the coastal zone over the last 50 years. A certain number of marshes overgrown with reeds can be maintained as bird habitats, but a too large expansion of this type reduces the openness of the beaches and therewith their aesthetic and recreational value.

The second largest land cover type is coniferous forest (3.1.2), which is represented in the coastal zone with

**Table 2.** CORINE land cover classes in the Estonian 200-m coastal zone. 1 = Total area in Estonia (ha); 2 = Total area in the 200-m coastal zone (ha); 3 = % from total area of Estonia; 4 = % of land cover class in 200 m coastal zone; 5 = area of land cover classes under nature protection, ha; 8 = % of land cover classes under nature protection in 200-m coastal zone.

Code	Short name of cover class	1	2	3	4	5	6
	<b>Artificial surfaces</b>	<b>84027</b>	<b>2237</b>	<b>2.7</b>	<b>4.7</b>	<b>179</b>	<b>8.0</b>
111	Continuous urban development	496	1	0.2	0.0	0	0.0
112	Discontinuous urban development	44225	924	2.1	1.9	143	15.5
121	Industrial or commercial units	17845	291	1.6	0.6	22	7.6
122	Road and rail network	3491	9	0.3	0.0	0	0.0
123	Port areas	980	633	64.6	1.3	8	1.3
124	Airports	2405	19	0.8	0.0	0	0.0
131	Mineral extraction sites	6882	42	0.6	0.1	0	0.0
132	Dump sites	3619	39	1.1	0.1	0	0.0
133	Construction sites	118	10	8.5	0.0	0	0.0
141	Green urban areas	2234	204	9.1	0.4	0	0.0
142	Sport and leisure facilities	1732	65	3.8	0.1	6	9.2
	<b>Agricultural areas</b>	<b>1465133</b>	<b>4924</b>	<b>0.3</b>	<b>10.4</b>	<b>1062</b>	<b>21.6</b>
211	Non-irrigated arable land	665937	615	0.1	1.3	175	28.5
231	Pastures	293304	646	0.2	1.4	100	15.5
242	Complex cultivation patterns	164682	424	0.3	0.9	12	2.8
243	Land principally occupied by agriculture	341210	3239	0.9	6.8	775	23.9
	<b>Forest and semi-natural areas</b>	<b>2577305</b>	<b>32011</b>	<b>1.2</b>	<b>67.3</b>	<b>8444</b>	<b>26.4</b>
311	Broad-leaved forest	442228	2043	0.5	4.3	583	28.5
312	Coniferous forest	852097	7156	0.8	15.0	1933	27.0
313	Mixed forest	847938	2502	0.3	5.3	527	21.1
321	Natural grasslands	41308	7148	17.3	15.0	2094	29.3
322	Moors and heathland	15771	3306	21.0	7.0	774	23.4
3241	Transitional woodland /scrub on mineral soil	228064	4717	2.1	9.9	1125	23.8
3242	Transitional wood-land/scrub on mire	140685	15	0.0	0.0	0	0.0
331	Beaches, dunes, sands	6495	4513	69.5	9.5	1303	28.9
333	Sparsely vegetated areas	2719	611	22.5	1.3	105	17.2
	<b>Wetlands</b>	<b>76044</b>	<b>8192</b>	<b>10.8</b>	<b>17.2</b>	<b>1536</b>	<b>18.7</b>
4111	Inland marshes	32337	7907	24.5	16.6	1379	17.4
4112	Open fens and transitional bogs	43299	12	0.0	0.0	0	0.0
421	Salt marshes	408	273	66.9	0.6	157	57.5
	<b>Water</b>	<b>209033</b>	<b>188</b>	<b>0.1</b>	<b>0.4</b>	<b>107</b>	<b>56.6</b>
511	Water courses	3329	9	0.3	0.0	0	0.0
512	Water bodies	204229	49	0.0	0.1	30	60.0
521	Coastal lagoons	1475	130	8.8	0.3	77	59.2
	<b>Total</b>	<b>4411542</b>	<b>47552</b>	<b>1.1</b>	<b>100.0</b>	<b>11328</b>	<b>23.8</b>

7156 ha (15% of the area) and the third largest are the semi-natural grasslands (3.2.1; note that these are called natural grassland in the CORINE system) with 7147 ha (15% of the area). The three first land cover types are followed by transitional woodland /scrub on mineral soil (3.2.4.1) with 4717 ha (9.9%) and beaches, dunes and sands (3.3.1) with 4512 ha (9.5%). The five largest land-use units cover 76% of the total 200-m coastal zone. The total area of the next land cover types is also over 1000 ha: moors and heathland (3.2.2) with 3305 ha, land principally occupied by agriculture, with significant areas of natural vegetation (2.4.3), mixed forest (3.1.3) with 2501 ha, broad-leaved forest (3.1.1) with 2043 ha. The overview in Table 2 presents a quantitative picture of

Estonian coastal zone land cover types, but considering the variability of the Estonian coast, this does not provide information on the land unit composition of concrete coastal sections. A more detailed account of given in Table 3 where the coastal land unit composition is analysed across different counties.

While the 200-m zone accounts for only 1.1% of the Estonian territory, several land cover types as distinguished in the CLC system occur with a high share in the coastal zone: salt marshes (CLC code 4.2.1; 67% of the Estonian territory), beaches, dunes, sands (3.3.1; 70%), port areas (1.2.3; 65%), inland marshes (4.1.1.1; 25%) as well as sparsely vegetated areas (3.3.3; 23%), moors and heathland (3.2.2; 21%) and natural grasslands (3.2.1;

**Table 3.** CORINE land cover classes in the Estonian 200-m coastal zone by county (ha). Tot Area = Total area of land cover class in the Estonian 200-m coastal zone.

Code	Short name of cover class	Counties							
		Tot Area	Ida-Virumaa	Lääne-Virumaa	Harjumaa	Hiiumaa	Saaremaa	Läänemaa	Pärnumaa
<b>Artificial surfaces</b>									
111	Continuous urban development	1	0	0	1	0	0	0	
112	Discontinuous urban development	924	99	72	505	2	77	128	41
121	Industrial or commercial units	291	68	0	144	0	60	2	17
122	Road and rail network	9	0	0	9	0	0	0	0
123	Harbour areas	633	0	0	391	79	74	61	28
124	Airports	19	0	0	0	5	14	0	0
131	Mineral extraction sites	42	21	0	9	0	12	0	0
132	Dump sites	39	39	0	0	0	0	0	0
133	Construction sites	10	0	0	10	0	0	0	0
141	Green urban areas	204	0	0	187	0	17	0	0
142	Sport and leisure facilities	65	19	0	46	0	0	0	0
<b>Agricultural areas</b>									
211	Non-irrigated arable land	615	293	0	30	28	161	74	29
231	Pastures	646	53	15	23	51	427	30	47
242	Complex cultivation patterns	424	4	0	216	3	72	12	117
243	Land principally occupied by agriculture	3239	155	336	831	176	776	160	805
<b>Forest and semi-natural areas</b>									
311	Broad-leaved forest	2043	17	63	585	341	605	307	125
312	Coniferous forest	7156	67	686	1371	1645	2147	914	326
313	Mixed forest	2502	485	142	638	499	386	202	150
321	Natural grasslands	7148	113	40	761	1314	2165	2148	607
322	Moors and heathland	3306	0	0	217	227	2614	236	12
3241	Transitional woodland /scrub on mineral soil	4717	108	195	586	982	1603	806	437
3242	Transitional wood-land/scrub on mire	15	0	0	0	0	15	0	0
331	Beaches, dunes, sands	4513	77	122	949	670	1968	572	155
333	Sparsely vegetated areas	611	0	0	49	29	271	163	99
<b>Wetlands</b>									
4111	Inland marshes	7907	52	289	468	351	2976	2013	1758
4112	Open fens and transitional bogs	12	0	0	12	0	0	0	0
421	Salt marshes	273	0	0	0	273	0	0	0
<b>Water</b>									
511	Water courses	9	0	0	2	0	0	2	5
512	Water bodies	49	0	0	0	0	15	26	8
521	Coastal lagoons	130	0	0	0	54	55	19	2
<b>Total</b>		47552	1670	1960	8040	6729	16510	7875	4768

17%). Noteworthy is the relatively high share of construction sites (1.3.3; 8.5%).

Table 2 (bold face) gives an overview of the coastal zone by types of land cover types. Artificial surfaces make use 4.7% of the coastal zone area, agricultural areas 10.4%, forest and semi-natural areas 67.3%, wetlands 17.2% and water bodies 0.4 %. The rather small proportion of artificial areas is a proof of the relatively good state of the nature of Estonian coasts when the CORINE land cover satellite photos were made. Since there are plans to make satellite photos on a regular basis, after certain time periods, the introduction of these methods will enable to study the dynamics of

changes of land cover types in the coastal zone. It would also be interesting to compare them with the coastal zones in other European (and not only European) countries. New all-European CORINE land cover inventory in the scale 1:50000 will be started in the very near future, thus giving possibilities to do even more detailed spatial analyses.



## Level of protection of the coastal zone

### *Legislative protection of the coastal zone*

The subject of the current paper is the coast in the sense of the Estonian Marine and Freshwater Coasts, Shores and Banks Act (RTI 1995, 31, 382), as the principal legislative document, regulating the use and protection of the coastal area of Estonia. The enactment establishes that coasts of the Baltic Sea in zones of low population density shall be 200 m wide. This paper examines the 200 m wide strip of land – a constituent part of the Baltic Sea coast – that is situated both in the mainland and insular parts of Estonia (see Fig. 1).

In the coastal zone several restrictions of human activities and management have been established by the Estonian Marine and Freshwater Coasts, Shores and Banks Act, the main purpose of which is to protect the preserved natural aspect of coastal areas:

- All construction activities in the coastal, shore and bank construction prohibition zone shall be prohibited. A construction prohibition zone shall be defined starting from the mean water level line. The width of the zone shall be: (1) for the coast of all islands: 200 m; (2) for the coast of mainland Estonia: 100 m.
- The width of the construction prohibition zone in coastal, shore and bank areas in zones of high population density shall be 50 m.
- The owner of the real property within a construction prohibition zone may apply from the state for free building title within land belonging to the state, which is located in the same region.
- Construction prohibition shall not apply to the construction, reconstruction and renovation of the facilities, undertaken in conformity with the general and detailed plans.
- Coastal, shore and bank areas may be extended or reduced in accordance with a general plan approved by a municipality. Reduction of the width of coastal, shore and bank areas are subject to the approval of the Minister of Environment.
- Creation of new zones of high population density in coastal, shore and bank areas is prohibited. Exceptions may be made by the Government of the Republic of Estonia upon the proposal of a municipality.
- Right for construction activities concerning real estate located in coastal, shore or bank areas, the land of which is meant for use for agricultural or forestry purposes, shall be subject to approval by the Minister of the Environment.
- The main function of the forests growing in the coastal areas of the Baltic Sea is to protect soil and water and to preserve recreation possibilities. These forests are classi-

fied as protective or preservation forests. Final felling of a forest in above mentioned areas shall not be permitted. The main function of forests in coastal, shore and bank areas may be changed with the approval of the Minister of the Environment.

- The width of coastal, shore and bank areas defined in this Act shall apply until a municipality shall specify it in accordance with the general plan of the municipality.
- The state may pre-empt the sale of real property lying wholly or partly within a construction prohibition zone. The right of pre-emption shall not be used in cases of inheritance.

As this is evident from the clauses above, considerable decisive rights have been passed over to local municipalities and the Minister of the Environment. In the cases when the 200-m coastal zone is situated in a protected area, restrictions, arisen from the Law on Protected Natural Objects (RT I 1994, 46/37, 773) shall be expanded to the particular location in addition to the protection enactments of coastal, shore and bank areas.

### *Protected areas in the coastal zone*

Territorial units under nature protection of different status (nature reserves, national parks, landscape reserves) account for ca. 11% of the Estonian territory (Ehrlich et al. 1999). Table 2 contains data on the protected land units in the 200-m coastal zone. The largest protected land cover type in the coastal zone is semi-natural grasslands (3.2.1) with 2094 ha, accounting for ca. 29% of the total area of the respective land cover type in the coastal zone. The maintenance of these land cover types depends on regular management, and management in turn requires financial support (Ehrlich 1997, 1999). In Estonian practice it is easier to obtain such support in protected areas than in other areas. The second largest land cover type in the coastal zone by total area under protection is the coniferous forest (3.1.2) with 1933 ha (27% of the total area of the respective land cover type in the 200-m zone) and the third largest is inland marshes (4.1.1.1; 1379 ha). These are followed by beaches, dunes and sands (3.3.1) with 1303 ha and transitional woodland/scrub on mineral soil (3.2.4.1) with 1125 ha.

The major protected land cover types in the coastal zone are water bodies (5.1.2) 60% of which are protected, followed by coastal lagoons (5.2.1) with 59% and salt marshes (4.2.1) with 57%. Through this protection coastal water bodies and lagoons can fulfil their function as a resting and breeding place for waterfowl.

In total 24% of the 200-m coastal zone is protected, which is more than double the percentage for Estonia as a whole (Table 2).

*Distribution of the coastal zone land cover types by county*

The geological variability of the coastal zone, which is found back in the CORINE land unit composition in the 200-m coastal zone, has been discussed by Orviku (1992). For the typology of the coastal zone based on the CLC classes, we have used an analysis of the land cover types across counties (Fig. 1b), which are the largest administrative units in Estonia (Table 3). Seven Estonian counties have a seacoast, including Saaremaa and Hiiumaa, the largest islands of Estonia.

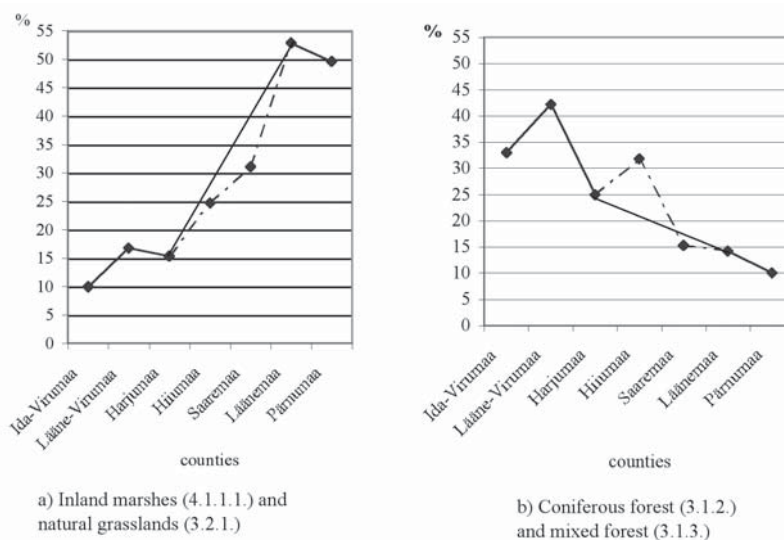
Table 3 presents the county-wise distribution of CLC classes in the 200-m coastal zone. The counties are geographically arranged, following the coastline from east to west (Fig. 1b). In the easternmost county – Ida-Viru – where a substantial part of the coastal zone includes coastal cliffs, the most dominating land cover types mixed forest while the importance of coniferous forests is small. On the other hand, half of the 42 ha of the country’s mineral extraction sites (1.3.1) are situated in Ida-Viru, which is the main mining region of Estonia. Coniferous forests form the predominant land cover type of the next county, Lääne-Viru, with a cover of 35%. The coastal zone of Harju county, the most densely populated county of Estonia, includes many land cover types, none of which with a high cover. Similarly to Lääne-Viru, coniferous forests are with 17% the most important type, followed by beaches, dunes and sand (3.3.1) with 12%. Hence this county has favourable recreation possibilities.

Harju county where the capital city Tallinn is situated, has the largest cover of urban-industrial areas. More than half the harbour areas (1.2.3) are found in Harju, the county with the largest human impact. The insular county of Hiiumaa is the most forested one in whole Estonia with

many coniferous forests and semi-natural grasslands. On the largest island Saaremaa there are five dominating land cover types: inland marshes with 18%, moors and heathlands with 16%, semi-natural grasslands with 13%, coniferous forests with 12% and beaches, dunes and sand also with 12%. Most of the Estonian coastal moors and heathlands (3.2.2) are found on Saaremaa. Generally speaking the replacement of open landscapes with reed beds (inland marshes) and juniper bushes is the biggest danger to the coasts of Saaremaa. In Lääne county semi-natural grasslands with 27% and inland marshes with 26% are nearly equally represented. In combination with coniferous forests (12%) they occupy almost two thirds of the coastal zone of the county. In the Matsalu Nature Reserve in this county the largest coastal pastures (CORINE type 3.2.1) are found. The coastal zone of the county is also an important feeding and resting site for migrating birds of international importance (Gren et al. 1997; Kastepõld 1998). In Pärnu county inland marshes occupy 37%, followed by agriculture and semi-natural grasslands with 13%. Overgrowing with reeds due to cessation of grazing is taking place also in Pärnu county.

The difference in land cover spectrum in the 200-m coastal zone of northern Estonia (Ida, Lääne-Viru, Harju) and western Estonia (Lääne, Pärnu County).

This difference is illustrated in Fig. 2. Coastal-zone counties are arranged geographically along the horizontal axis, from Ida-Viru County bordering the Russian Federation in the Northeast to Pärnu County bordering Latvia in the Southwest (see Fig. 1b). The vertical axis indicates the percentage share of the area of coastal zone land cover types 3.2.1 + 4.1.1.1 and 3.1.2 + 3.1.3 in the respective coastal zones. From the continental part of Estonia in the direction from Ida-Viru County to Pärnu County (unbroken line) the share is rising for semi-



**Fig. 2.** Share of the dominating land cover units in the coastal zone counties of Estonia

natural grasslands and inland marshes (3.2.1 + 4.1.1.1), while clearly falling for coniferous and mixed forests (3.1.2 + 3.1.3).

Islands, especially Hiiumaa, represent a transition from northern to western Estonia (see Fig. 1; points connected by a dotted line).

## Conclusions

1. The 200-m coastal zone of Estonia is very diverse, according to the CORINE Land Cover classification. Out of the 34 CLC classes represented in Estonia, 30 are found in the 200-m coastal zone.

2. Three larger land cover types, which occupy more than 7000 ha in the 200-m coastal zone, are inland marshes, coniferous forests and semi-natural grasslands. The location of land cover types varies by county. In the coastal zone of the northern Estonian counties the dominating land cover type is coniferous forests followed by land principally occupied by agriculture, mixed forests, and beaches, dunes and sand. In the coastal zone of western Estonia (including the islands) the dominating land cover type is inland marshes followed by semi-natural grasslands.

3. The Estonian coastal zone is generally in a good natural condition. The proportion of artificial surfaces throughout the zone is merely 4.7% and agricultural landscapes cover only ca. 10%. In the coastal zone, after pasturing and mowing ceased, the existing alvars and seashore meadows were replaced by inland marshes, mostly reed bed areas, and transitional woodland/scrub. Thus, due to this change in land use, semi-natural communities have been replaced by natural communities rather than by artificial surfaces or agricultural areas.

4. Of the 200-m coastal zone 24% is under protection, which is more than twice the value for Estonia as a whole (11%). Legislative protection of the coastal zone is presently sufficient.

5. As CORINE land cover types are considered to be the land cover classification standard throughout Europe, it gives a good opportunity for further comparative analyses of the coastal zones of different countries and regions. Moreover, updating of the original CLC database has been initiated, allowing for the identification of land cover changes. It consists of satellite image 'snap shots' of Europe (IMAGE2000) and an updating of the CLC database for the year 2000 (CLC2000) showing land cover changes in Europe during the period 1990-2000 (Anon. 2000). In the beginning of 2003 Estonia will have completed already ca. 25% of CLC2000.

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## References

- Anon. 2000. *European Topic Centre on the Terrestrial Environment*. <http://terrestrial.eionet.eu.int/CLC2000>
- Ehrlich, Ü. 1997. Management of coastal and floodplain meadows. In: Leibak, E. & Lutsar, L. (eds.) *Estonian coastal and floodplain meadows*, pp. 78-92. WWF, Tallinn, EE.
- Ehrlich, Ü. 1999. Ecological economics of coastal and riparian seminatural grasslands (A case study of Estonia). In: *The joint conference land-ocean interactions: Managing coastal ecosystems Nov. 9-13*, pp. 1163-1174. Antalya, TU.
- Ehrlich, Ü., Habicht, K. & Krusberg, P. 1999. Territories with limited economic utilisation as a factor of economic and social development. In: Ennuste, Ü. & Wilder, L. (eds.) *Harmonisation with the Western economics: Estonian economic developments and related conceptual and methodological frameworks*, pp. 303-327. Estonian Institute of Economics at Tallinn Technical University, Tallinn, EE.
- Gren, I.-M., Ehrlich, Ü. & Pedersen, M.B. 1997. *Economic valuation of flood plains and coastal wetlands in Estonia*. Estonian Fund for Nature, WWF Denmark. Tallinn, EE.
- Kastepõld, T. 1998. *Matsalu looduskaitseala (Matsalu Nature Reserve)*. Lääne Maavalitsus, Haapsalu, EE.
- Kukk, T. & Kull, K. 1997. Puisniidud (Wooded meadows). *J. Est. Mar.* 2: 1-249.
- Leibak, E. & Lutsar, L. (eds.) 1996. *Estonian coastal and floodplain meadows*. Estonian Fund for Nature and WWF Denmark, Tallinn, EE.
- Martin, G., Palo, A. & Möller, K. 1998. Introduction to the marine and coastal environment of Estonia. In: Red List of marine and coastal biotopes and biotope complexes of the Baltic sea, Belt sea and Kattegat, compiled by H. von Nordheim & D. Boedeker – Baltic Sea Environment Proceedings No. 75, pp. 30-35. Helsinki, FI.
- Meiner, A. (ed.) 1999. *Land cover of Estonia. Implementation of the CORINE Land Cover project in Estonia*. Tallinn, EE.
- Orviku, K. 1992. *Characterization and evolution of Estonian seashores*. Ph.D. Thesis University of Tartu, EE.
- Raukas, A. (ed.) 1995. *Estonia Nature*. Tallinn, EE.

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**App. 1.** Three levels of the CORINE Land Cover system. Names in italics refer to Land Cover classes not present in Estonia; bold names refer to classes the definition of which was modified or where 4th level national subclasses were added.

Level 1	Level 2	Level 3
1. Artificial surfaces	1.1. Urban fabric	1.1.1. Continuous urban fabric 1.1.2. Discontinuous urban fabric
	1.2. Industrial, commercial and transport units	1.2.1. Industrial or commercial units 1.2.2. Road and rail networks and associated land 1.2.3. Port areas 1.2.4. Airports
	1.3. Mine, dump and construction sites	1.3.1. Mineral extraction sites 1.3.2. Dump sites 1.3.3. Construction sites
	1.4. Artificial non-agricultural vegetated areas	1.4.1. Green urban areas 1.4.2. Sport and leisure facilities
2. Agricultural areas	2.1. Arable land	2.1.1. Non-irrigated arable land <i>2.1.2. Permanently irrigated land</i> <i>2.1.3. Rice fields</i>
	2.2. Permanent crops	<i>2.2.1. Vineyards</i> <i>2.2.2. Fruit trees and berry plantations</i> <i>2.2.3. Olive groves</i>
	2.3. Pastures	2.3.1. Pastures
	2.4. Heterogeneous agricultural areas	<i>2.4.1. Annual crops associated with permanent crops</i> 2.4.2. Complex cultivation patterns 2.4.3. Land principally occupied by agriculture, with significant areas of natural vegetation <i>2.4.4. Agro-forestry areas</i>
3. Forest and semi-natural areas	3.1. Forests	3.1.1. Broad-leaved forest 3.1.2. Coniferous forest 3.1.3. Mixed forest
	3.2. Shrub and/or herbaceous vegetation associations	<b>3.2.1. Semi-natural grassland</b> <b>3.2.2. Moors and heathland</b> <i>3.2.3. Sclerophyllous vegetation</i> <b>3.2.4. Transitional woodland shrub</b>
	3.3. Open spaces with little or no vegetation	3.3.1. Beaches, dunes and sand plains <i>3.3.2. Bare rocks</i> 3.3.3. Sparsely vegetated areas 3.3.4. Burnt areas <i>3.3.5. Glaciers and perpetual snow</i>
4. Wetlands	4.1. Inland wetlands	<b>4.1.1. Inland marshes</b> <b>4.1.2. Peatbogs</b>
	4.2. Coastal wetlands	<b>4.2.1. Salt marshes</b> <i>4.2.2. Salines</i> <i>4.2.3. Intertidal flats</i>
5. Water bodies	5.1. Inland waters	5.1.1. Water courses 5.1.2. Water bodies
	5.2. Marine waters	<b>5.2.1. Coastal lagoons</b> <i>5.2.2. Estuaries</i> 5.2.3. Sea and ocean