Mapping of coastal Natura 2000 habitats with high spatial resolution airborne imagery and LIDAR data using a multiscale object-based approach

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Introduction

- Coastal areas are amongst the most threatened natural areas in the world
- Many of the habitats within the coastal zone of The Netherlands are in the list of Annex I of the Habitat Directive (HD) as Natura 2000 habitat types.
- In mapping procedures some habitats were overseen or left out
- Semi automatic habitat classification in the coastal region has already been applied several times
- However, mainly focusing on the stabilized dunes and the salt marshes habitats
- Multi scale object based approach can substantially improve the classification

Research Questions

- *Is a rulebased multiscale object oriented hierarchal image analysis of airborne remote sensing imagery and ancillary data from different sources suitable for the detection and mapping of coastal and marine Natura 2000 habitat types?*
- *Are the found results more accurate in comparison with other researches in the coastal zone?*

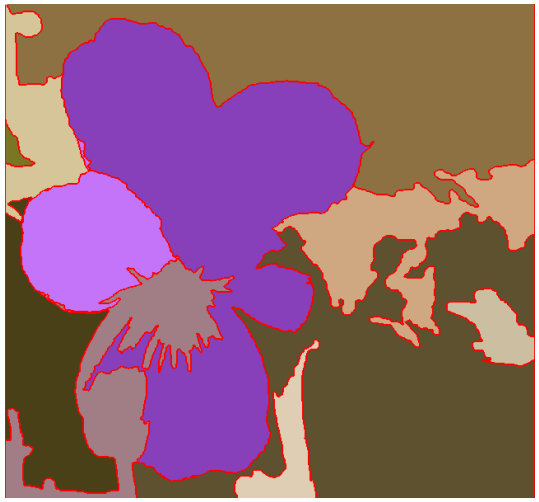
OBIA

- Object based image analysis (OBIA)
  - Clustering pixels to larger “meaningful” objects.
  - The size of the created objects is determined by the scale parameter.
  - The scale parameter is a dimensionless threshold which controls the heterogeneity of the objects.

Multiscale

- Human perception

Scale parameter 750

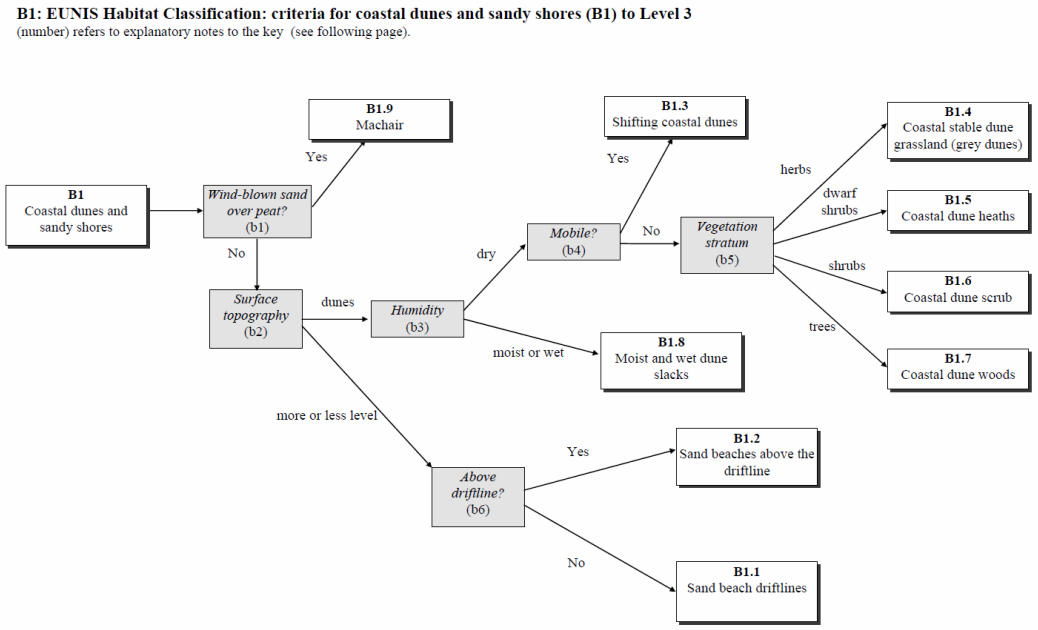


Scale parameter 250

Scale parameter 50

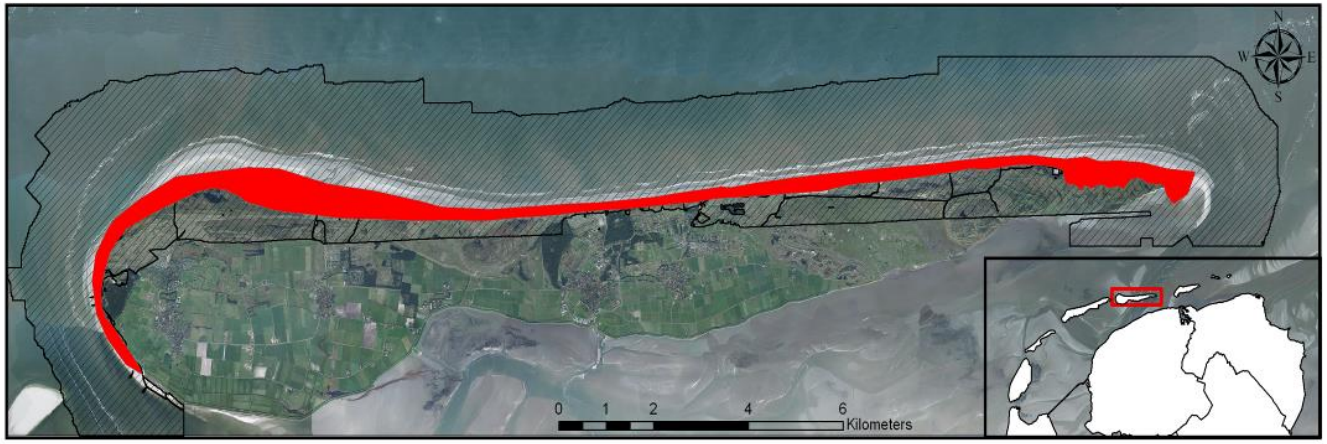
Classification method of Natura2000

- CORINE and EUNIS
  - Bottom up vs top down
- EUNIS:
  - Four levels
  - Rules
  - Interlinked:
    - NATURA 2000
    - CORINE



Research area

- Case study: coastal zone of Ameland
  - Red: sampled area
  - Striped: classified area

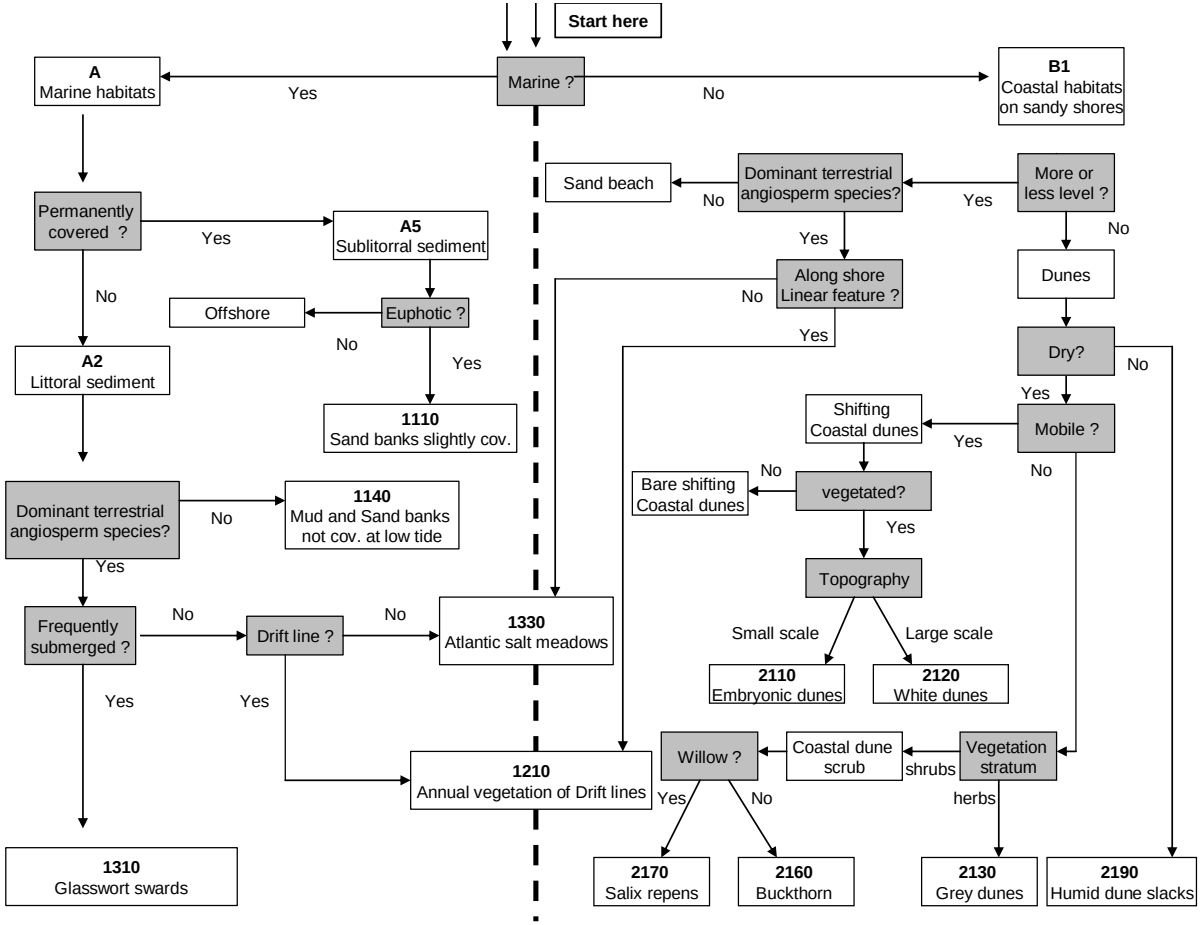


Habitats of interest

level 3	Natura 2000 code
offshore	
nearshore	1110
foreshore	1140
glasswort swards	1310
atlantic salt meadows	1330
driftlines	1210
bare dunes	
sandflats	
embryonic dunes	2110
white dunes	2120
grey dunes	2130
buckthorn	2160
creeping willow	2170
trees	
sand blowout	
humid dune slacks	2190

Methods

- Classification Key (EUNIS derived)



Materials

- Data available:

	Materiaal	Source	Type	Kwality	hor. resolution (m)	bands / vert. resolutie (m)	coordinate system / Projection	date	time	tide	area
discarded	Imagery 2007	NAM	Raster	very good	0.5	VNIR	RD	1-4-2007	14:50	low tide	Ameland (-middle part) / Schiermonnikoog (-middle part)
	Imagery 2006	alterra	Raster	bad	0.5	VNIR	RD	3-7-2006	13:22	high tide	Netherlands
	DEM 2000	AHN	Raster	average	5	0.15	RD	herst/winter		high tide	Netherlands
selected	Imagery 2008	alterra	Raster	good	0.25	True color (NIR arrives in August)	RD			low tide	all the island (April)/ Netherlands (Augustus)
	Imagery 2008	NAM	Raster	good	0.5	False color	RD			almost low tide	Ameland (-middle part)
	AHS	Alterra	Raster	good	5	126 bands	UTM/ WGS84	1-1-2006		low tide	Ameland
	RAW LIDAR 2008	Rijkswaterstaat	Raster	good	1	0.16	RD	herst/winter		low tide	North sea shore of all islands
	DEM 2008	Rijkswaterstaat	Points	good		0.18	RD	herst/winter		low tide	North sea shore of all islands
	JARKUS	Rijkswaterstaat	Extrapolated lines (raster)	good	20	0.1	RD	1986-2006		NA	Entire north sea shore (also offshore)
	Fielddata	Alterra	Points	good	5		RD	april and July 2009		NA	coastal zone of Ameland

Methods

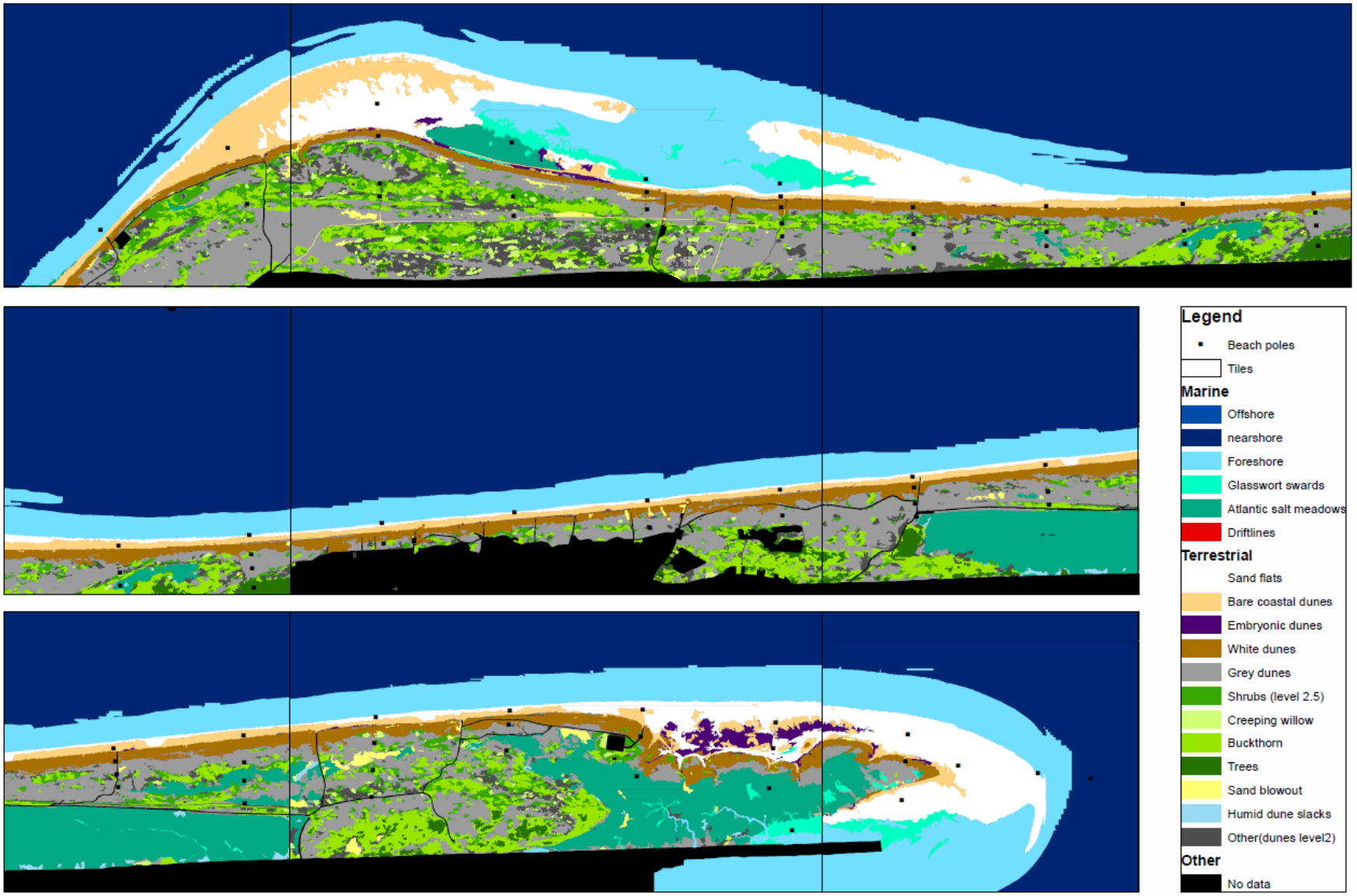
- Software used: Definiens Developer 7.0
- The image divided in tiles (hardware limitations)
- Areas not of interest masked
- Image layers: False Color, True Color, DEM and Vegetation height (LIDAR derived)
- First segmentation based on DEM
- Second and third based on True color imagery (highest resolution)
- Thresholds (rules) based on by forehand known variables or found by iterations

Results

- Found parameters

Domain level 1 (EUNIS)	Heigth above MASL	Zonation level 2 (this study	Heigth above MASL	Stdev slope	Brightness	Habitat (level 3)	Natura 2000 code	Stdv. Slope	NVDI	Stdv Red	veg height (m)	….enclosed by…...	distance to	shape	Wetness (NIR/Green)
marine	[-∞, MSHT]	offshore	[-∞, euphotic]			offshore									
		nearshore	[Euphotic, MLST]			near shore	1110								
		foreshore	[MSLT, MSHT)			foreshore	1140		[-∞, median]						
						Glasswort swards	1310		[median, ∞]						
			[MALT, MAHT)			Atlantic salt meadows	1330		[median, ∞]						
terrestrial	[MSHT, ∞]	backshore	[MSHT, ∞]	[-∞, mean]	OR [95% qt, ∞]	Driftlines	1210		[-∞, median]					length / width > 7	
						Sandflat		[-∞, mean]	[-∞, median]						
						Embryonic dunes	2110	[mean, 75% qt]	[-∞, median]	[median, ∞]			beach < 30		
						Bare dunes		[mean, 75% qt]	[-∞, median]	[-∞, median]					
		dunes		[mean, ∞]		Sandblowout						backshore, dunes			
						White dunes	2120	[75% qt, ∞]	[-∞, 75% qt]			embryonic dunes, white dunes	beach < 100m		
						Grey dunes	2130	[mean, 75% qt]	[75% qt, 90 % qt]		[0, 0.3]				
						Creeping willow	2170	[mean, 75% qt]	[90% qt, ∞]		[0.3, 1]			roundness <1	
						Buckthorn	2160	[mean, 75% qt]	[90% qt, ∞]		[0.3, 1]			roundness >1	
						Humid dune slacks		[mean, 75% qt]	[90% qt, ∞]		[0.5, ∞]	Salicornia, Dunes			[98% qt, ∞]
						Trees		[mean, 75% qt]	[90% qt, ∞]		[1, ∞]				

Map level3


Legend
Beach poles
Tiles
Marine
Offshore
nearshore
Foreshore
Glasswort swards
Atlantic salt meadows
Driftlines
Terrestrial
Sand flats
Bare coastal dunes
Embryonic dunes
White dunes
Grey dunes
Shrubs (level 2.5)
Creeping willow
Buckthorn
Trees
Sand blowout
Humid dune slacks
Other(dunes level2)
Other
No data
N
W
E
S
0
0.5
1
2
Kilometers

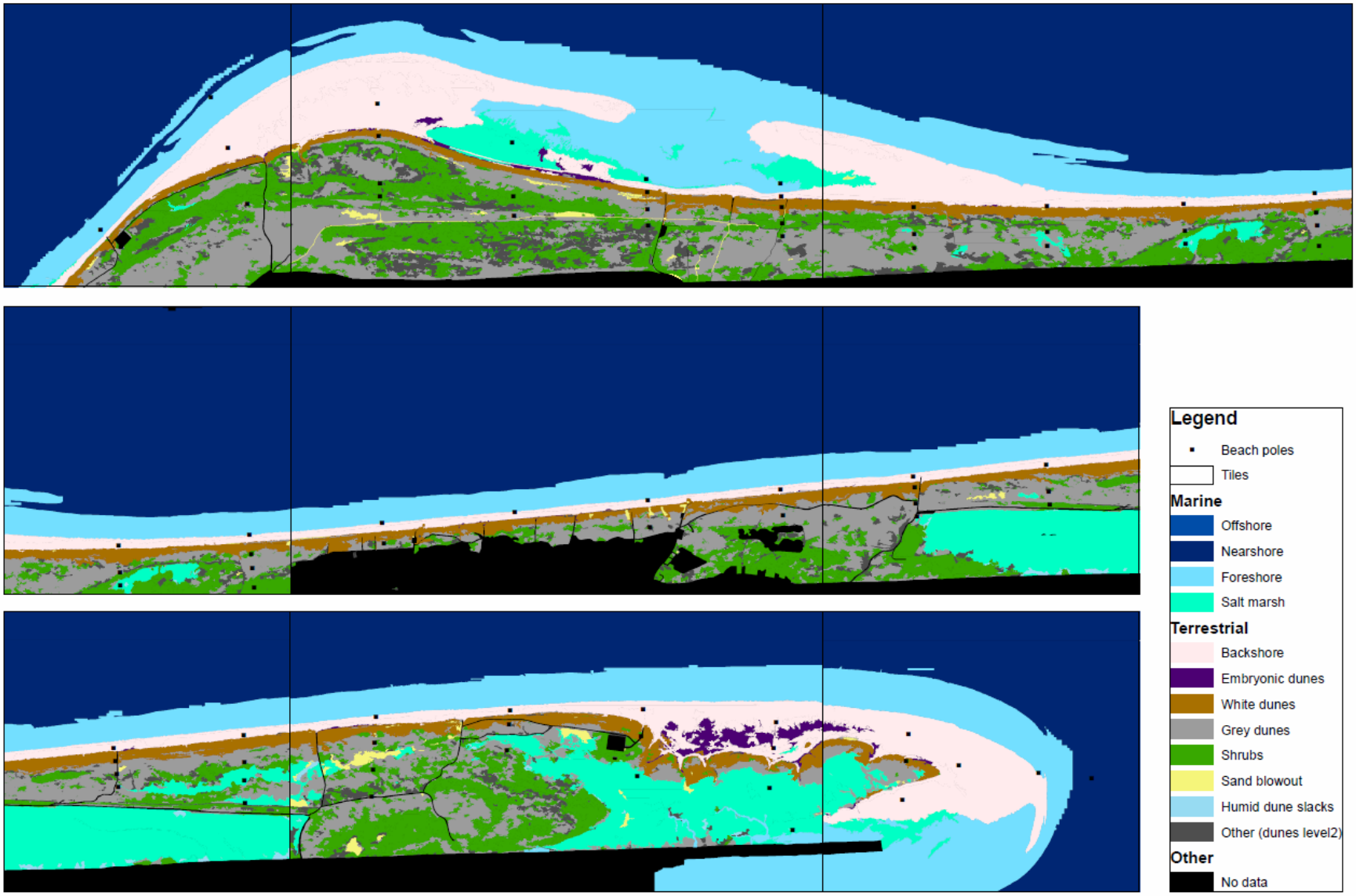
Results

- Overall accuracy:
- Confusion:
  - Sand flats, bare dunes and drift lines
  - Buckthorn and creeping willow
  - Humid dune slacks, Atlantic and glasswort salt marshes
  - Next in succession

	level 1	level2	level 3	level2.5
overall accuracy	95.6	76.5	48.7	64
KHAT	0.94	0.53	0.41	0.68

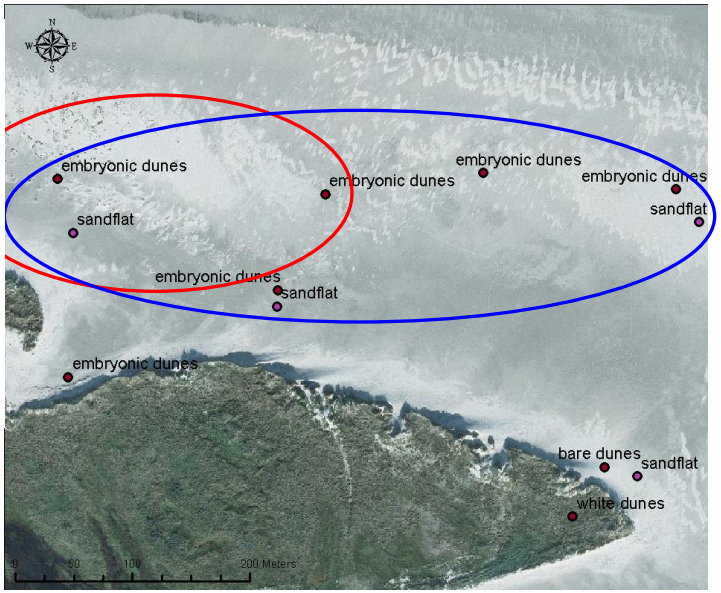
field \ image	shrubs	buckthorn	embryonic dunes	grey dunes	intertidal	creeping willow	atlantic salt meadow	dunes (other)	humid dune slacks	glasswort swards	sandflat	bare dunes	driftlines	white dunes	Grand Total	Producers%
shrubs															0	0
buckthorn	7	5		9		3		2		2				7	35	14.28571429
embryonic dunes			10								20	8	1		39	25.64102564
grey dunes	2	1		26				1				1		20	51	50.98039216
intertidal					35					2	5				42	83.33333333
creeping willow	4	2		8										3	17	0
atlantic meadow			3		3					1	6	6			19	0
dunes (other)															0	0
humid dune slacks		1					6								7	0
glasswort swards					2					6	4				12	50
sandflat					3		1				30	14			48	62.5
bare dunes				1							16	21	1	4	43	48.8372093
driftlines					1						2	11			14	0
whitedunes	2		5	2				1				6		66	82	80.48780488
Grand Total	15	9	18	46	44	3	7	4	0	11	83	67	2	100	409	sum tot
Users%	0	55.55556	55.555556	56.52174	79.5455	0	0	0	0	54.54545455	36.1446	31.3432836	0	66	sum diag	199

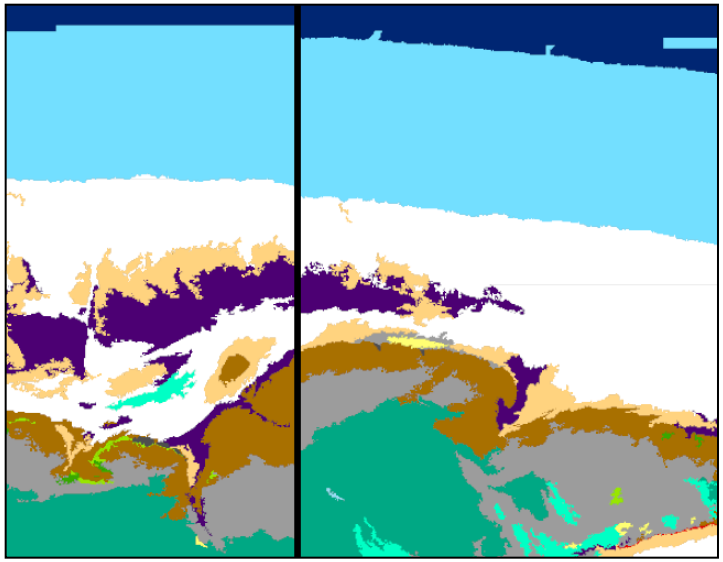
Map level 2.5

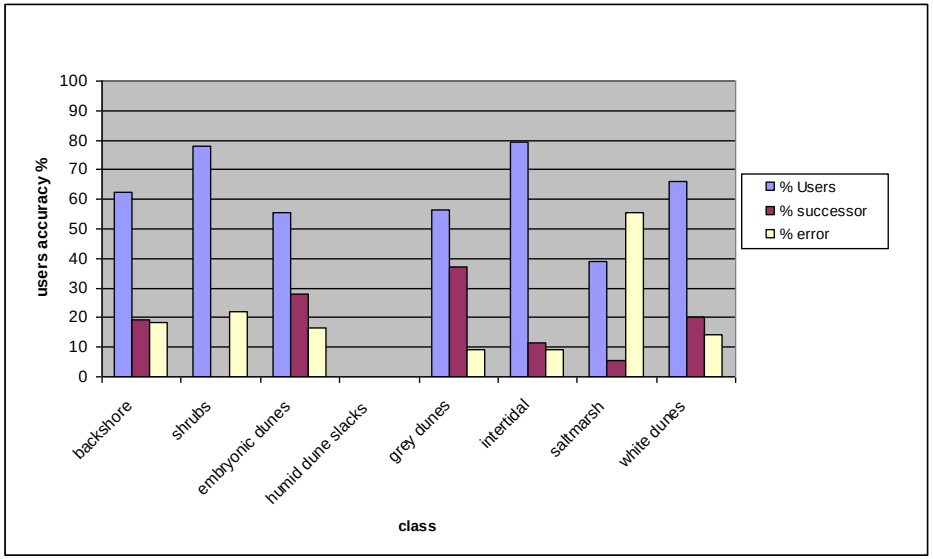

Legend
Beach poles
Tiles
Marine
Offshore
Nearshore
Foreshore
Salt marsh
Terrestrial
Backshore
Embryonic dunes
White dunes
Grey dunes
Shrubs
Sand blowout
Humid dune slacks
Other (dunes level2)
Other
No data
N
W
E
S
0
0.5
1
2
Kilometers

Discussion

- What is causing the errors?
  - Time difference data sources
  - Lidar data quality
  - Edge effects







Discussion

- In comparison with other researches

research	area	data source	method	detail	overall accuracy
Lee & Shan 2003	Sandy shore	LIDAR, Satelite	supervsied (ML)	level 2	94%
Bock *et al.* 2005	Forests, Coastal Areas	Satelite, Airborne, DEM, thematic	Rulebased and NN	level 2	86%
Brown 2004	Sandy shore, Saltmarsh	DTM, Slope, Airbone	supervised (ML, NN)	level 2.5	80-90%
de Lange *et al* . 2004	Sandy shore (stable dunes)	Hyperspectral	supervised (SAM)	level 3	60-70%
Chust *et al.* 2007	shore with hard substrate	LIDAR (high res, intensity), Airborne	supervised (ML)	level 3	93%
Ekeboom & Erkkillä 2002	Sandy shore (mobile)	Panchromatic images	manual	level 3	39-47%
This research	Sandy shore (mobile)	DTM, vegh, Airborne	Rulebased	level 3	49%

Conclusion

- To classify the coastal Natura 2000 habitats accurate this method has potential. However at the highest detail it delivers not a satisfactory results.
- Studies conducted in the more or less fixed dune communities have found better results.
- Studies conducted in a dynamic coastal environment (rare) have found similar results.
- In comparison, this research have found equal results.