Systems, landscapes and vegetation of the Iles Eparses *(South-West Indian Ocean)****: geobotanical survey of Europa island***

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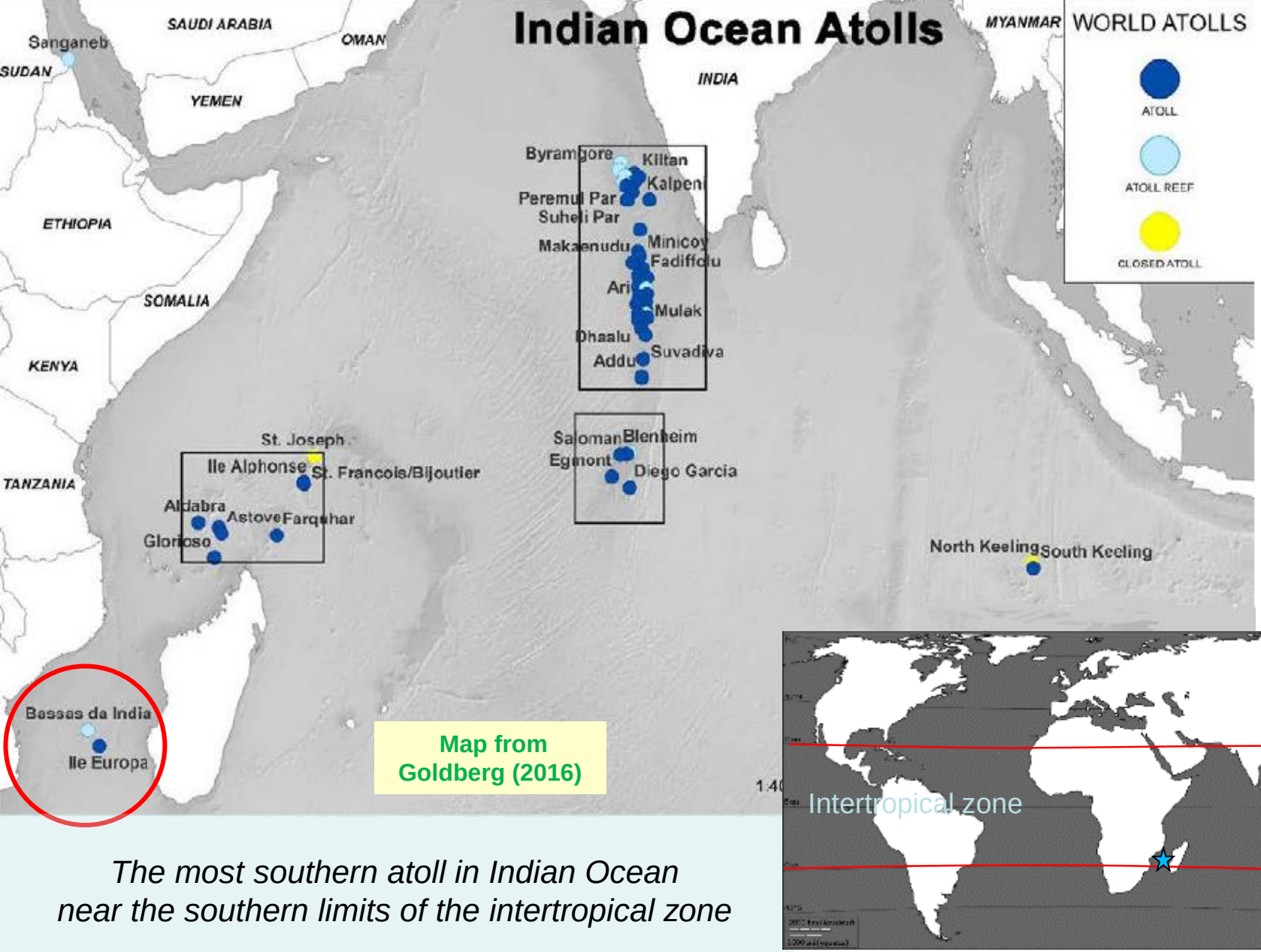
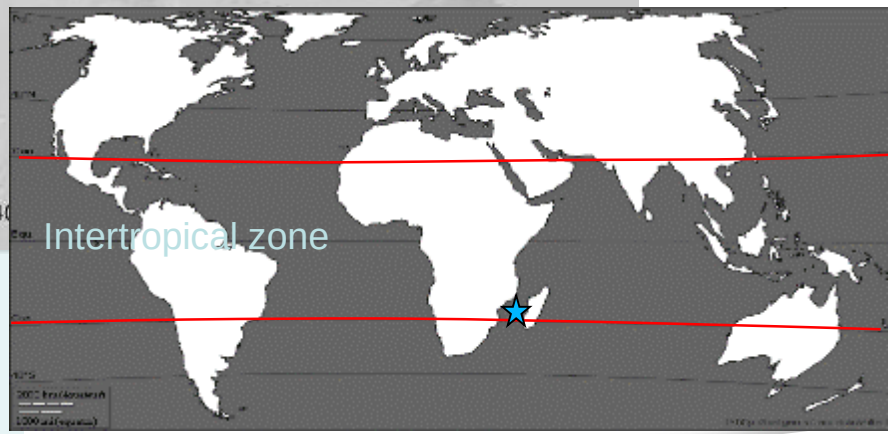
Island Biology 2019, Saint-Denis, July 8, 2019

Great Frigatebird [Frégate du Pacifique] (***Fregata minor***)

Europa: an isolated island in the middle of the Mozambique Channel

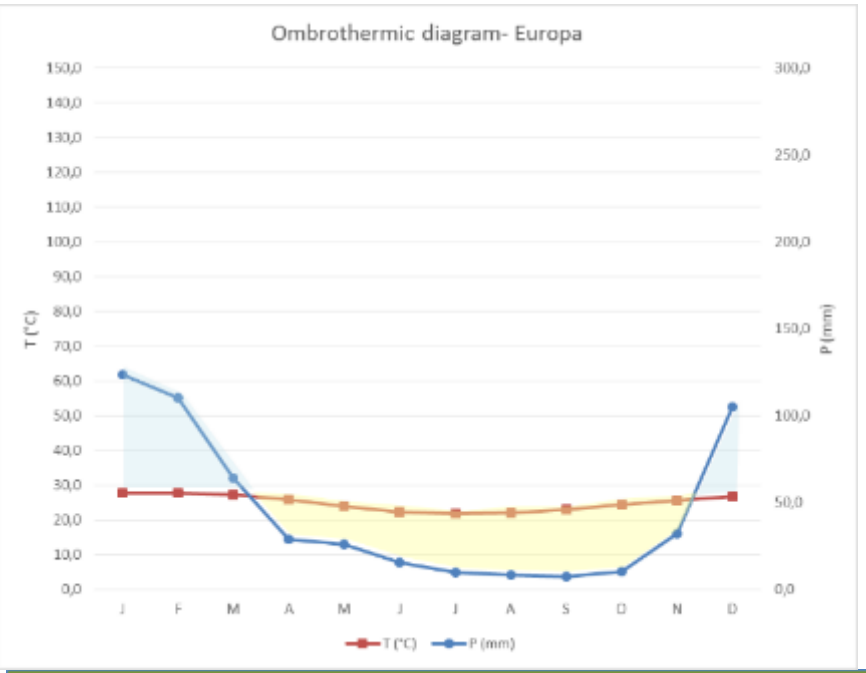


Map from Goldberg (2016)



The most southern atoll in Indian Ocean near the southern limits of the intertropical zone

Europa: atoll n° 14 in Goldberg's classification of atolls (2016)



weather station of Europa since 1951

a valuable source for studying climate change

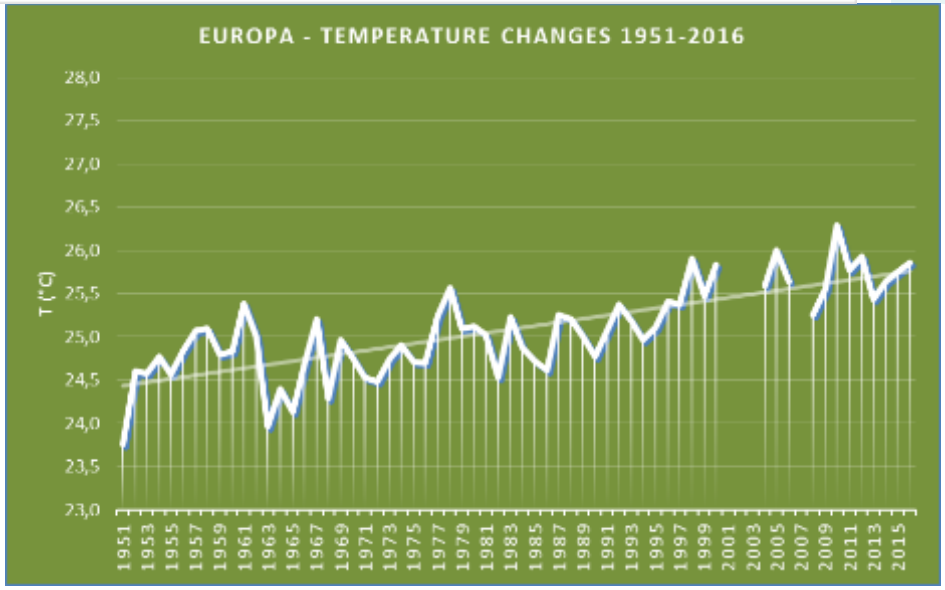
with some annual gaps since the automation of the station

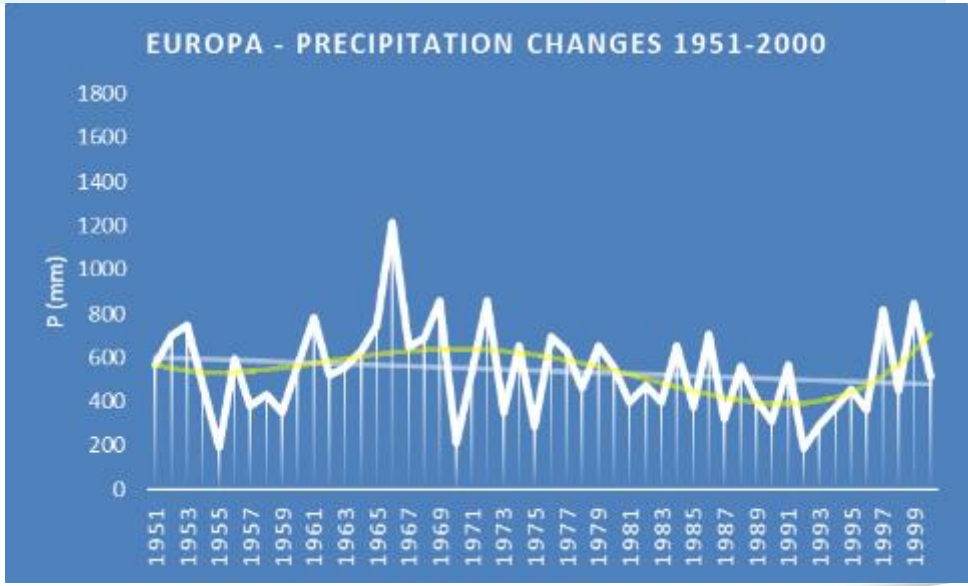
average annual precipitation (1951-1999): **541 mm** [434,5 mm (2006-2016)]

8-9 dry months (monthly precipitation < 30 mm)

average annual temperature (2006-2016) : **24,9° C** [25,7°C (2006-2016)]

trends since 1951: warmer (1°C increase) and drier



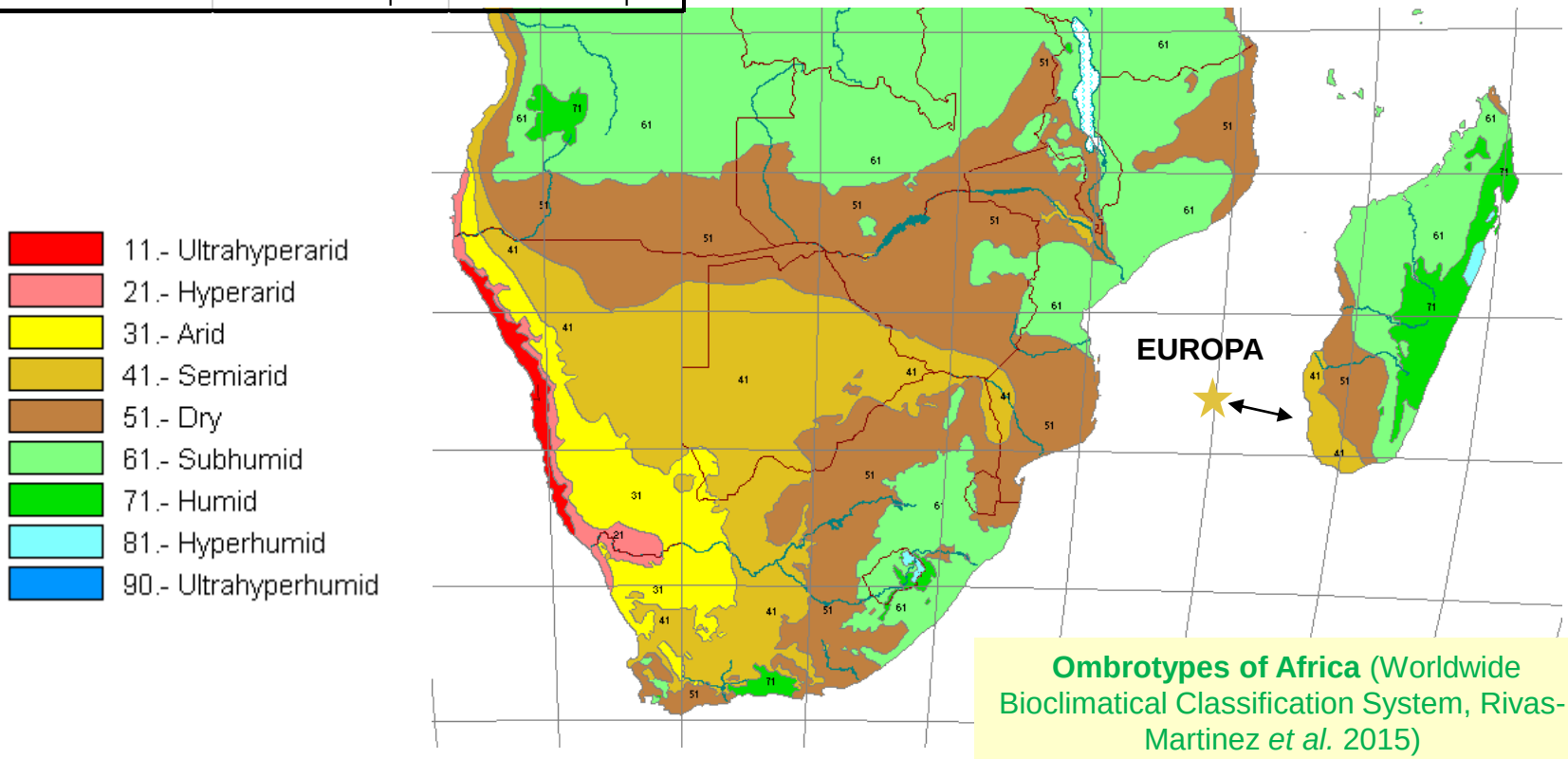


Climate of Europa: current and change since 1951

Bioclimate of Europa Island		
Period	1951-1999	2006-2016
Macrobioclimate	tropical	tropical
Bioclimate	xeric tropical	xeric tropical
Annual ombrothermic index (I_o)	**1,81**	**1,41**
Ombrotype	semiarid	semiarid
Ombrothermic horizon	upper semiarid	lower semiarid
Thermicity index (I_t)	**684**	**708**
Thermotype	thermotropical	thermotropical
Thermotypic horizon	lower thermotropical	lower thermotropical

Bioclimatic parameters and indices according to Rivas Martínez *et al.* (2011) and Worldwide Bioclimatical Classification System

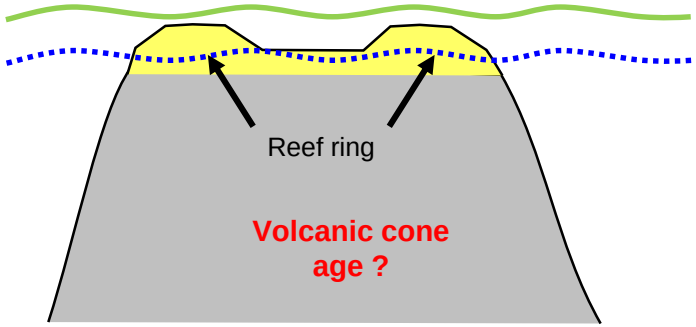
Allows a global comparison of the Europa bioclimate



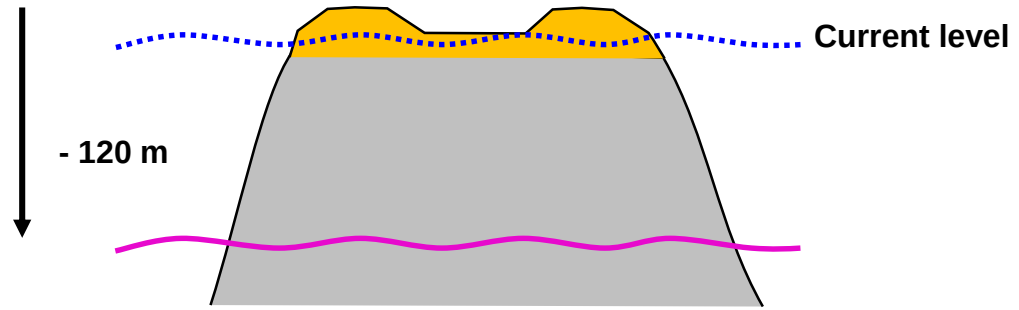
Ombrotypes of Africa (Worldwide Bioclimatical Classification System, Rivas-Martinez *et al.* 2015)

An original atoll with semi-arid bioclimate, close to the semi-arid type of SW of Madagascar

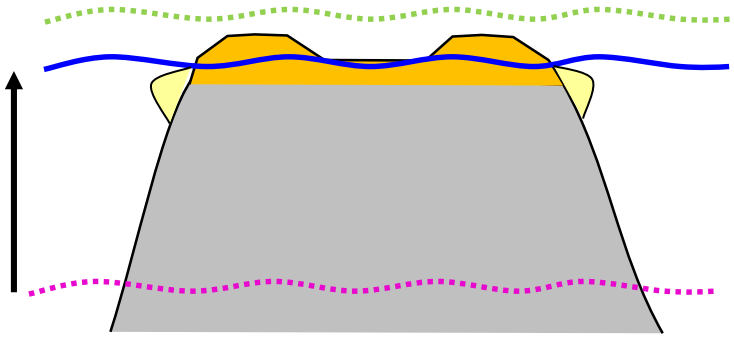
Thermic maximum of the interglacial
Riss / Würm
- 120 000 BP



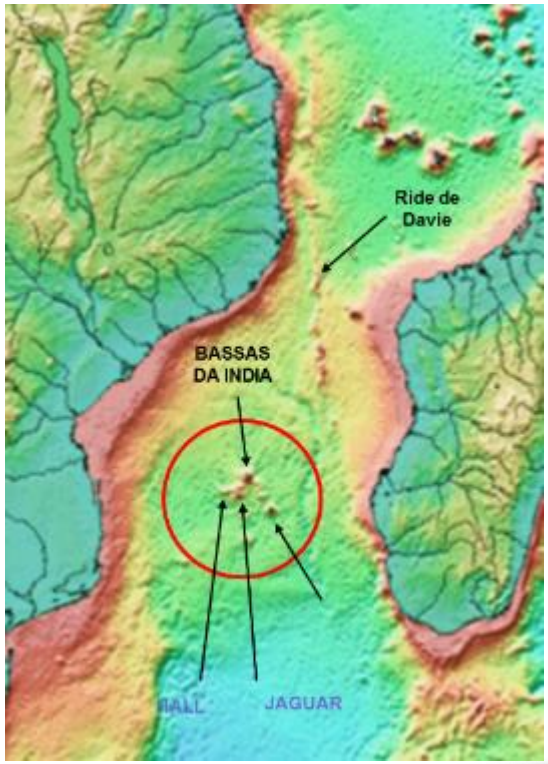
Glacial thermic minimum
Würm
- 19 000 BP



Current period



Δ : - 8 m



Sea level macro-oscillation since the thermic optimum Riss / Würm

Pioneer mangrove on coral dissolution mud (↗)

Relict coral (“mushrooms”) within inner saltmarsh on coral mud (➔)

Inner lagoon digging hypothesis (Delépine *et al.* 1976)

Reed-footed booby [Fou à pieds rouges] **(*Sula sula*)**

Vegetation and landscape survey: methods of investigation and overall results

- **Inventory of vascular flora** (2006-2016)
  - updated account recently published in Atoll Research Bulletin (Boullet, Hivert & Gigord 2018)
- **Vegetation analysis**
  - phytosociological survey (sigmatist method)
  - 529 phytosociological relevés (2006-2016)
  - ordination and classification of relevés (Ginkgo, University of Barcelona)
  - development of a typology of vegetation and habitats
  - 51 vegetation units (whose 17 plant associations and 26 other communities not formally recognized at association level)
- **Dynamico-catenal (landscape) analysis**
  - landscape phytosociological survey (study of series and geoseries of vegetation)
  - inductive (50 symphytosociological relevés and 90 transects of vegetation) and deductive approaches
  - 19 series of vegetation, 8 geoseries representing 8 major systems of vegetation

The 8 systems of vegetation

LITTORAL (mediolittoral / supralittoral) **floor**


Malagasy dry coastal dunes [Dl]


Mozambican saltmarshes and salty steppes [S]


West-indian coral lagoon mangroves [M]


Indopacifique coastal coral shingles [C]


West-malagasy coastal coral gravels [G]

supralittoral ← mediolittoral

hydrosere

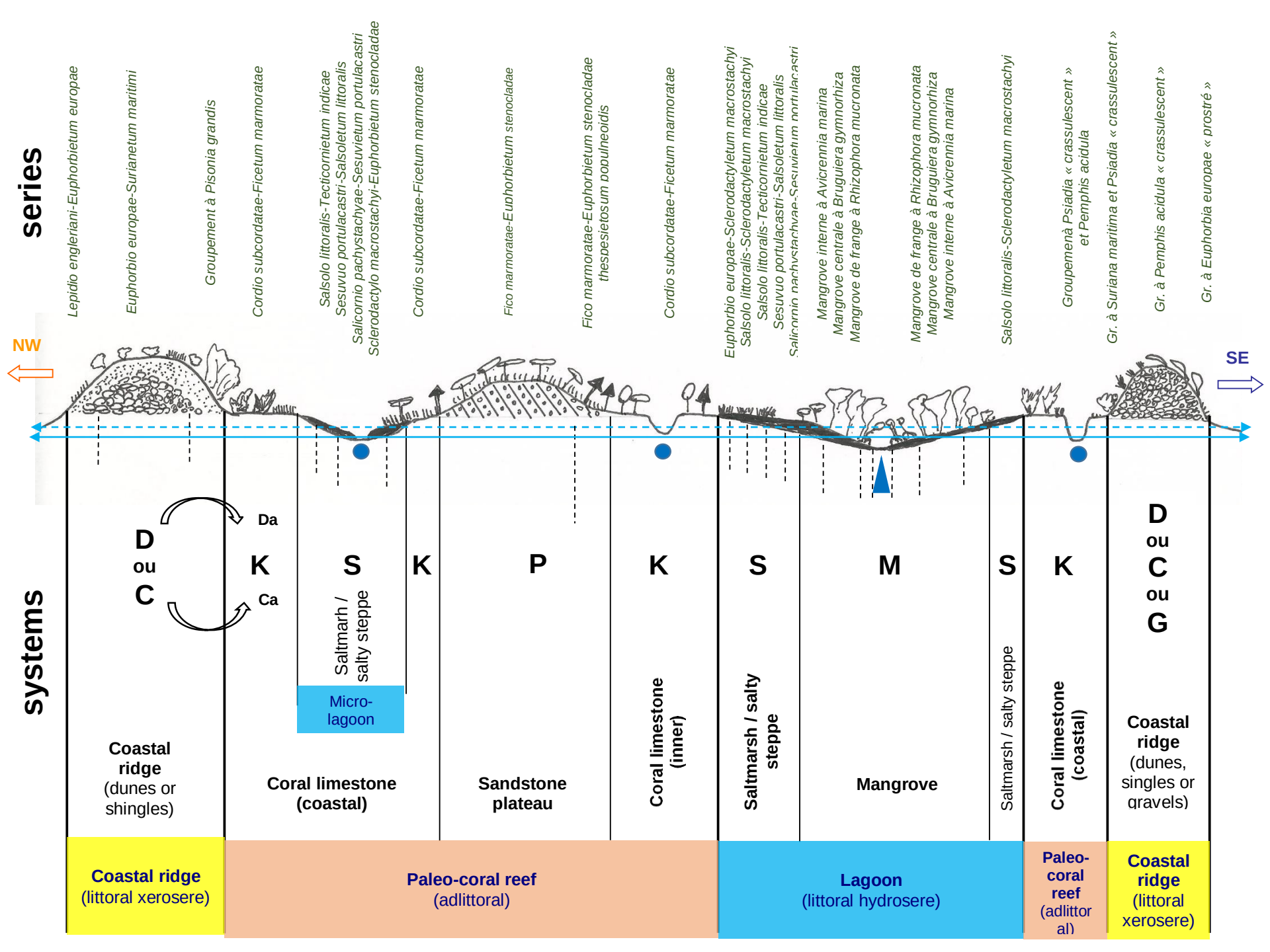

West-malagasy adlittoral dunes [Da]

ADLITTORAL floor

West-malagasy sandstone plateau [P]

xerosere


West-malagasy coral limestone [K]


series
Lepidio engleriani-Euphorbietum europae
Euphorbio europae-Surianetum maritimi
Groupement à Pisonia grandis
Cordio subcordatae-Ficetum marmoratae
Salsolo littoralis-Tecticornietum indicae
Sesuvuo portulacastri-Salsoletum littoralis
Salicornio pachystachyae-Sesuvietum portulacastri
Sclerodactylo macrostachyi-Euphorbietum stenocladae
Cordio subcordatae-Ficetum marmoratae
Fico marmoratae-Euphorbietum stenocladae
Fico marmoratae-Euphorbietum stenocladae thespesietosum populneoidis
Cordio subcordatae-Ficetum marmoratae
Euphorbio europae-Sclerodactyletum macrostachyi
Salsolo littoralis-Sclerodactyletum macrostachyi
Salsolo littoralis-Tecticornietum indicae
Sesuvuo portulacastri-Salsoletum littoralis
Salicornio pachystachyae-Sesuvietum portulacastri
Mangrove interne à Avicrennia marina
Mangrove centrale à Bruguiera gymnorhiza
Mangrove de frange à Rhizophora mucronata
Mangrove de frange à Rhizophora mucronata
Mangrove centrale à Bruguiera gymnorhiza
Mangrove interne à Avicrennia marina
Salsolo littoralis-Sclerodactyletum macrostachyi
Groupemenà Psiadia « crassulescent » et Pemphis acidula
Gr. à Suriana maritima et Psiadia « crassulescent »
Gr. à Pemphis acidula « crassulescent »
Gr. à Euphorbia europae « prostré »
NW
SE
systems
D ou C
Da
Ca
K
S
Saltmarh / salty steppe
K
P
K
S
M
S
K
D ou C ou G
Micro-lagoon
Coastal ridge (dunes or shingles)
Coral limestone (coastal)
Sandstone plateau
Coral limestone (inner)
Saltmarsh / salty steppe
Mangrove
Saltmarsh / salty steppe
Coral limestone (coastal)
Coastal ridge (dunes, singles or gravels)
Coastal ridge (littoral xerosere)
Paleo-coral reef (adlittoral)
Lagoon (littoral hydrosere)
Paleo-coral reef (adlittoral)
Coastal ridge (littoral xerosere)

White-tailed Tropicbird of Europa [Paille-en-queue à brins blancs d'Europa]

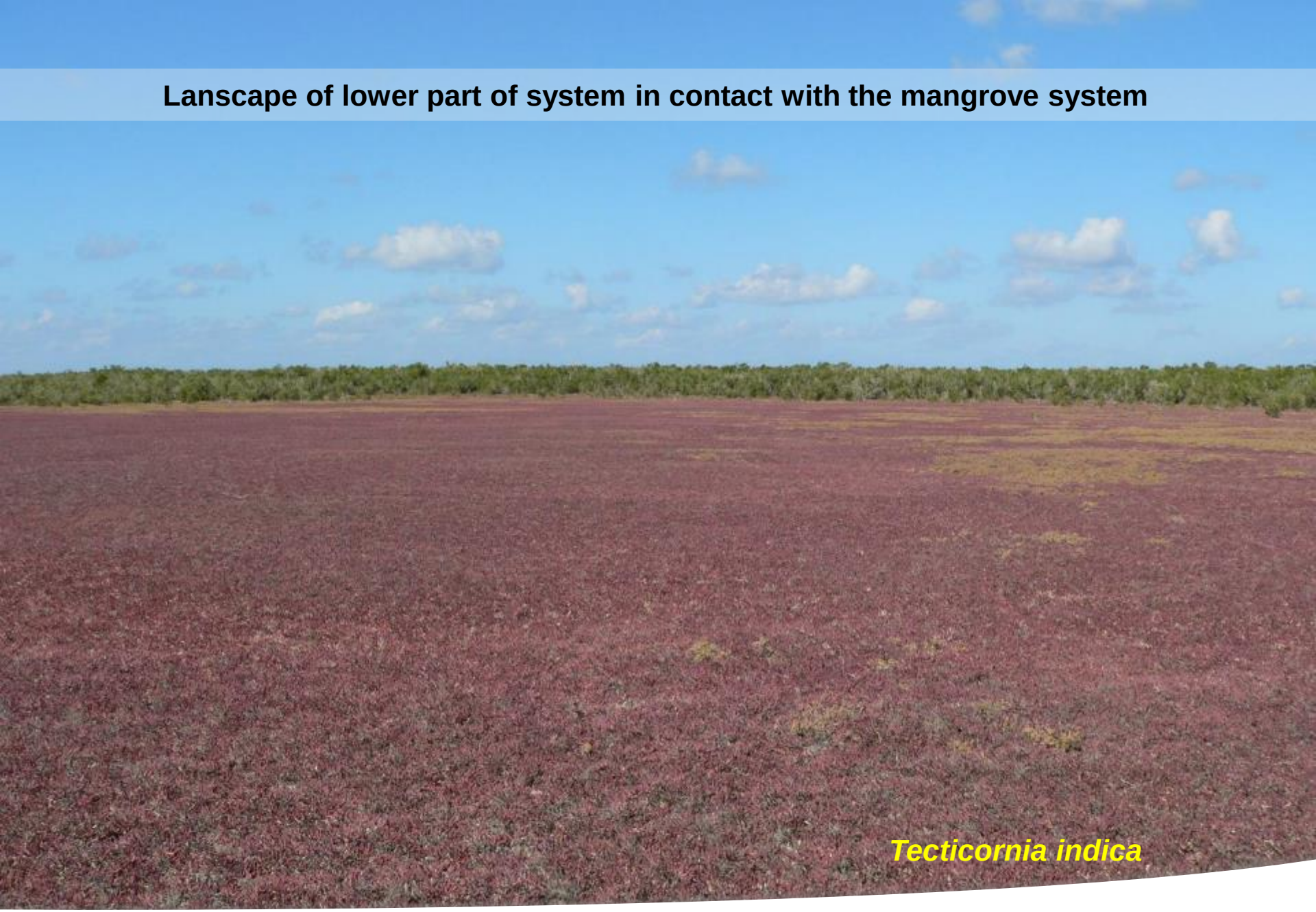
(***Phaeton lepturus europae***)

One example of system

2 dominant and structurant species (crassulaceous Chenopodioideae) in saltmarshes

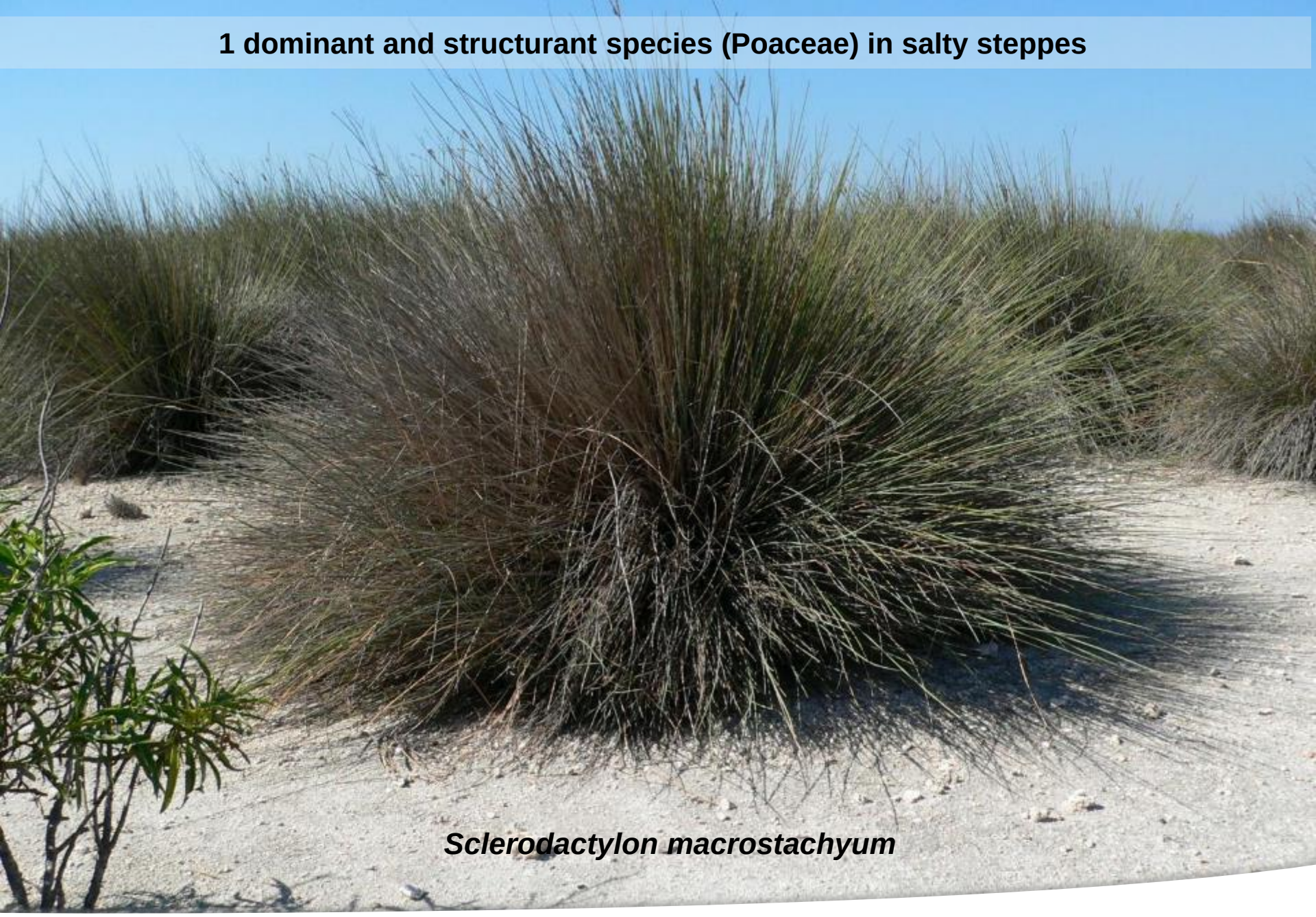
« Mozambican saltmarshes and salty steppes » system on coral dissolution mud

Lanscape of lower part of system in contact with the mangrove system



« Mozambican saltmarshes and salty steppes » system on coral dissolution mud

1 dominant and structurant species (Poaceae) in salty steppes



Sclerodactylon macrostachyum

Lanscape of salty steppe in middle part of system

« Mozambican saltmarshes and salty steppes » system on coral dissolution mud

salinity gradient

Sesuvium portulacastrum **mediolittoral saltmarsh**

Sesuvium portulacastrum - Salsola littoralis **very lower supralittoral saltmarsh**

Salsola littoralis - Halosarcia indica **lower supralittoral saltmarsh**

Salsola littoralis - Sclerodactylon macrostachyum **middle supralittoral steppe / saltmarsh**

Sclerodactylon macrostachyum upper supralittoral subsalty steppes

< 1 m

médiolittoral

lower

supralittoral

upper

topographic gradient

serie 1

serie 2

serie 3

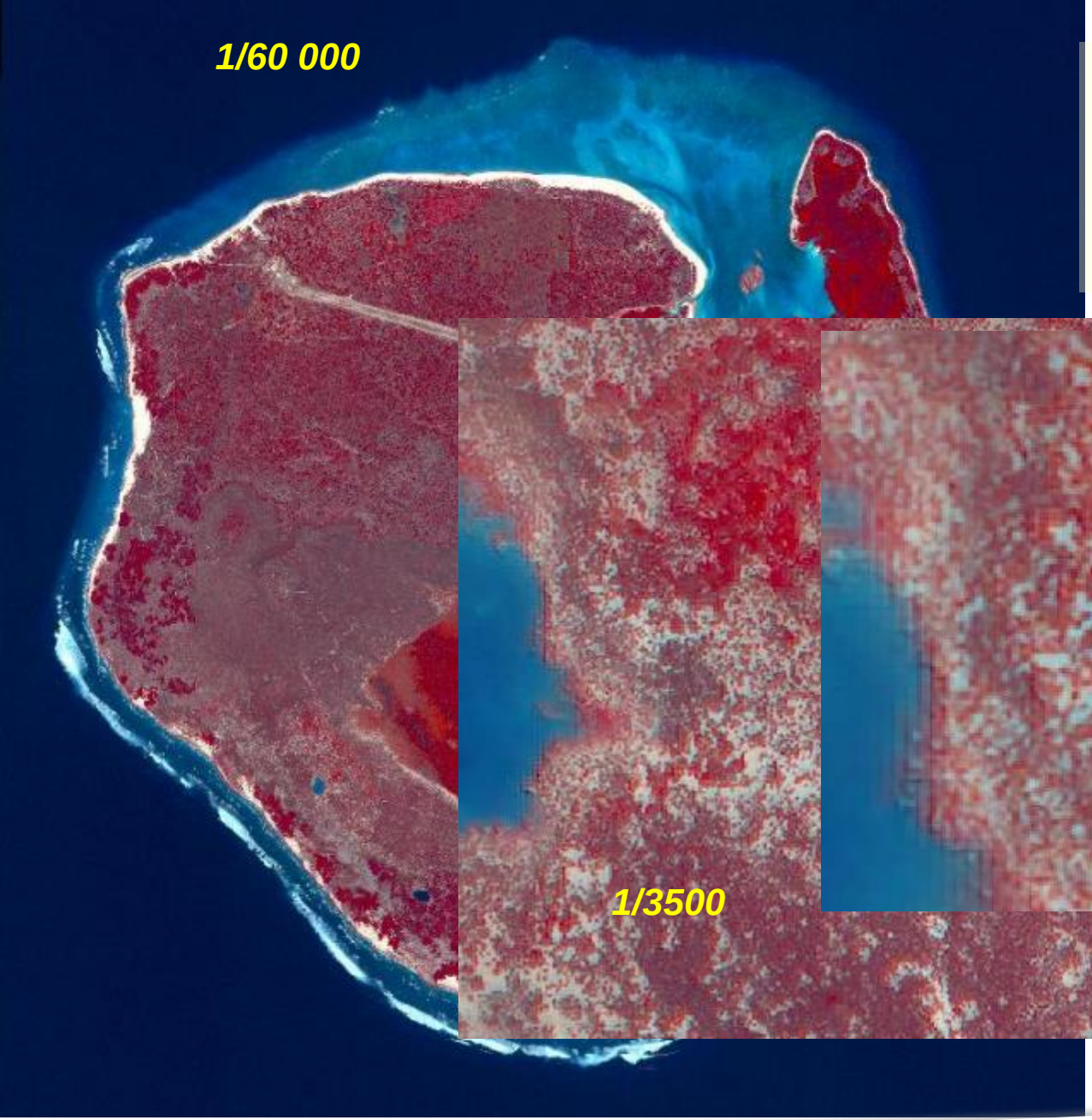
serie 4

series 5-6

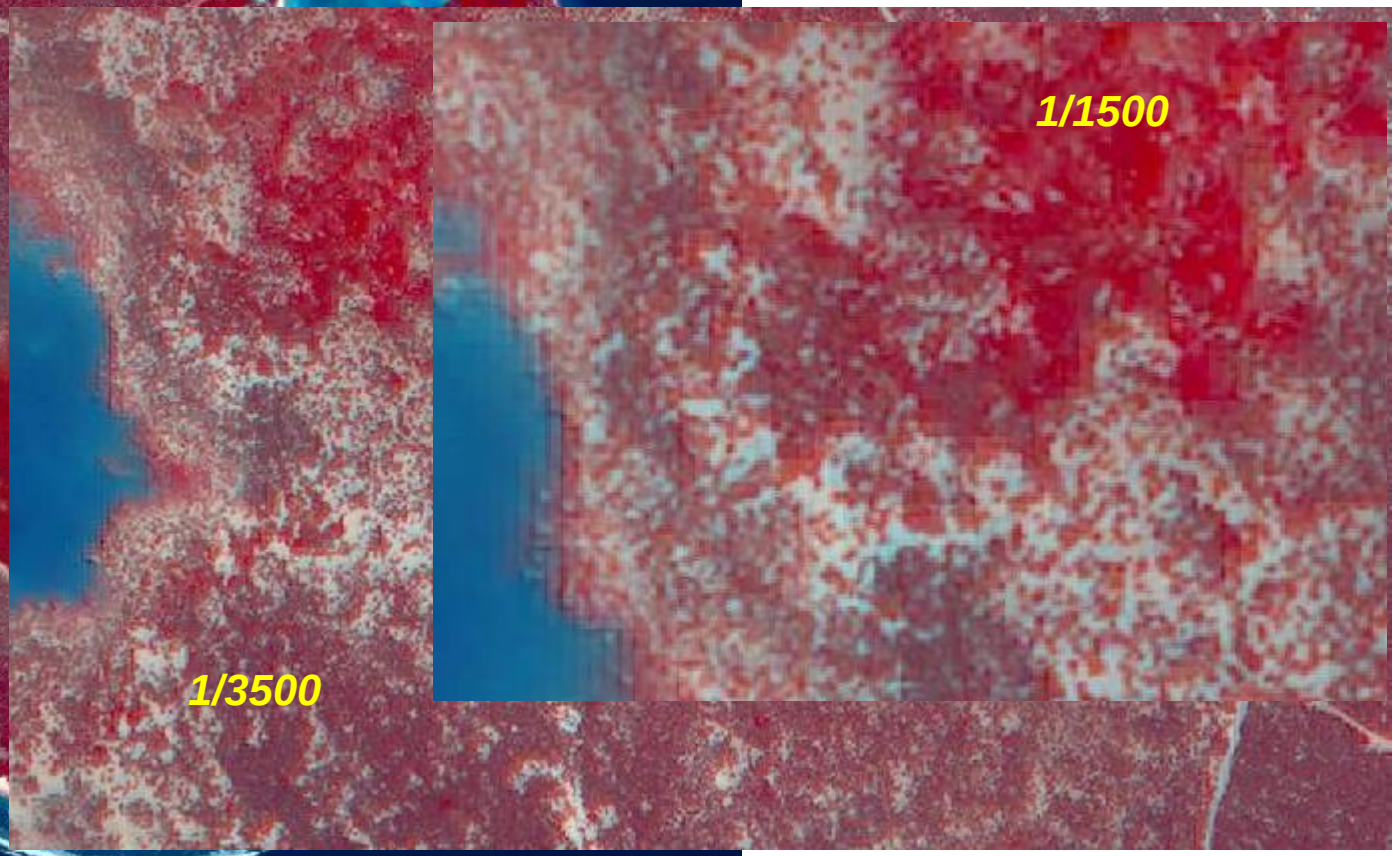
Topographic and salinity gradient of saltmarshes ans salty steppes system

Geobotanical map of systems of Europa island: methods

Malagasy pond heron [Crabier blanc] **(*Ardeola idae*)**

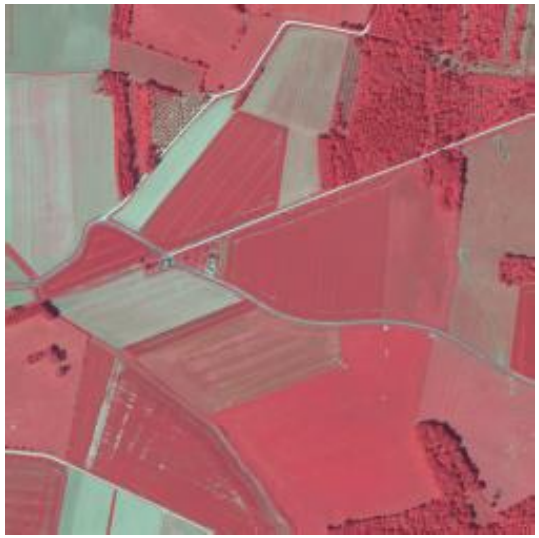


Resolution:
0,7 m (panchromatic mode)
2,8 m (multiband mode, RGB channels)
re-sampled at 0,5 cm



Support of map: satellite image Pleiade (29/07/2013, CNES (2013) Distribution AIRBUS DS)

HOW DOES THE SEGMENTATION SOFTWARE WORK ?



False color IRG image (Infrared displayed as red, red displayed as green, green displayed as blue)

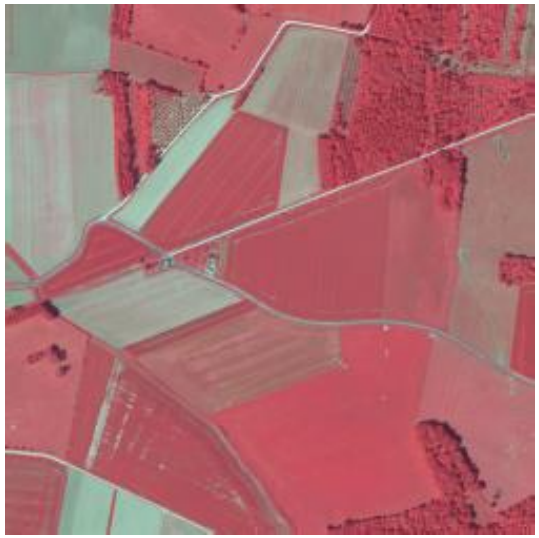
Grayscale gradient magnitude image (image band with maximum change (slope) is retained)

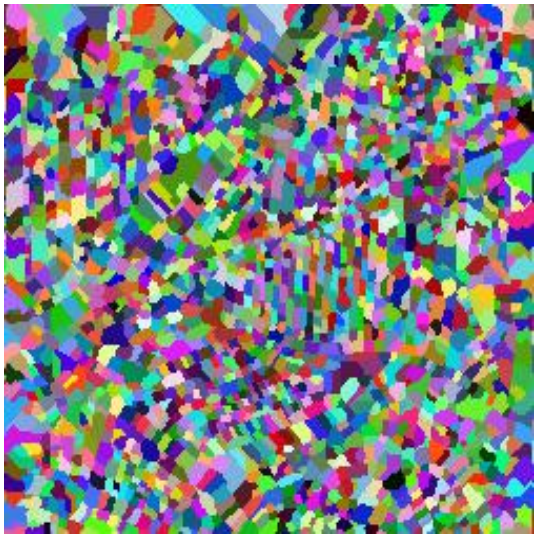
Watershed transformation: the image is treated like a topographic map, with the brightness of each point representing its height. The algorithm simulates the flooding of the image

Pyram ➔ see Guigues, L., Cocquerez, J.P., and Le Men, H. (2006). Scale-Sets Image Analysis. *Int. J. Comput. Vis.* 68, 289–317

Image segmentation by « Pyram » developed by IGN for CarHAB (french national program of habitat's mapping)

HOW DOES THE SEGMENTATION SOFTWARE WORK ?



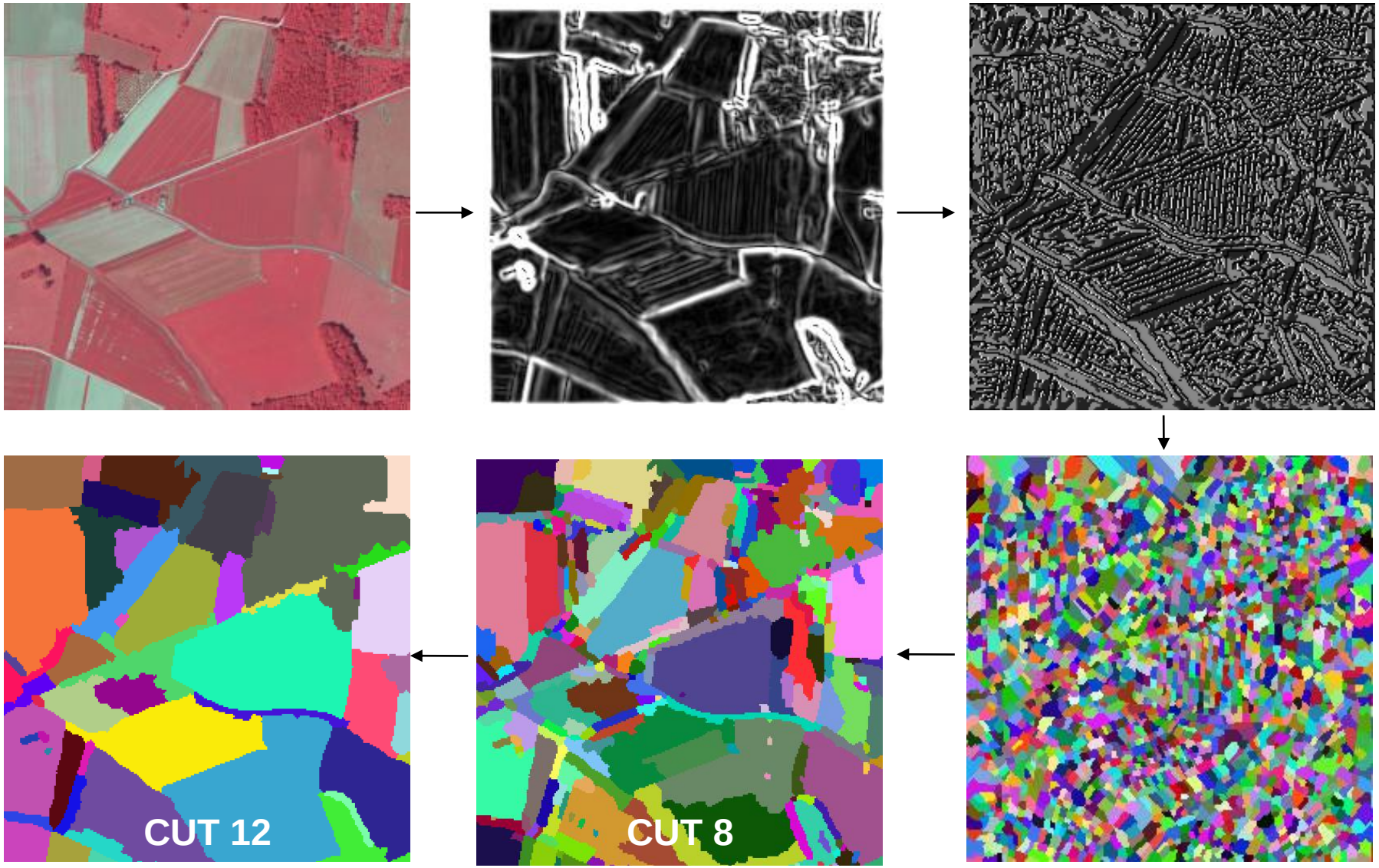


This leads to an over-segmented image to which a “scale climbing” algorithm is applied to produce a pyramid of images, where regions are merged with varying intensity.

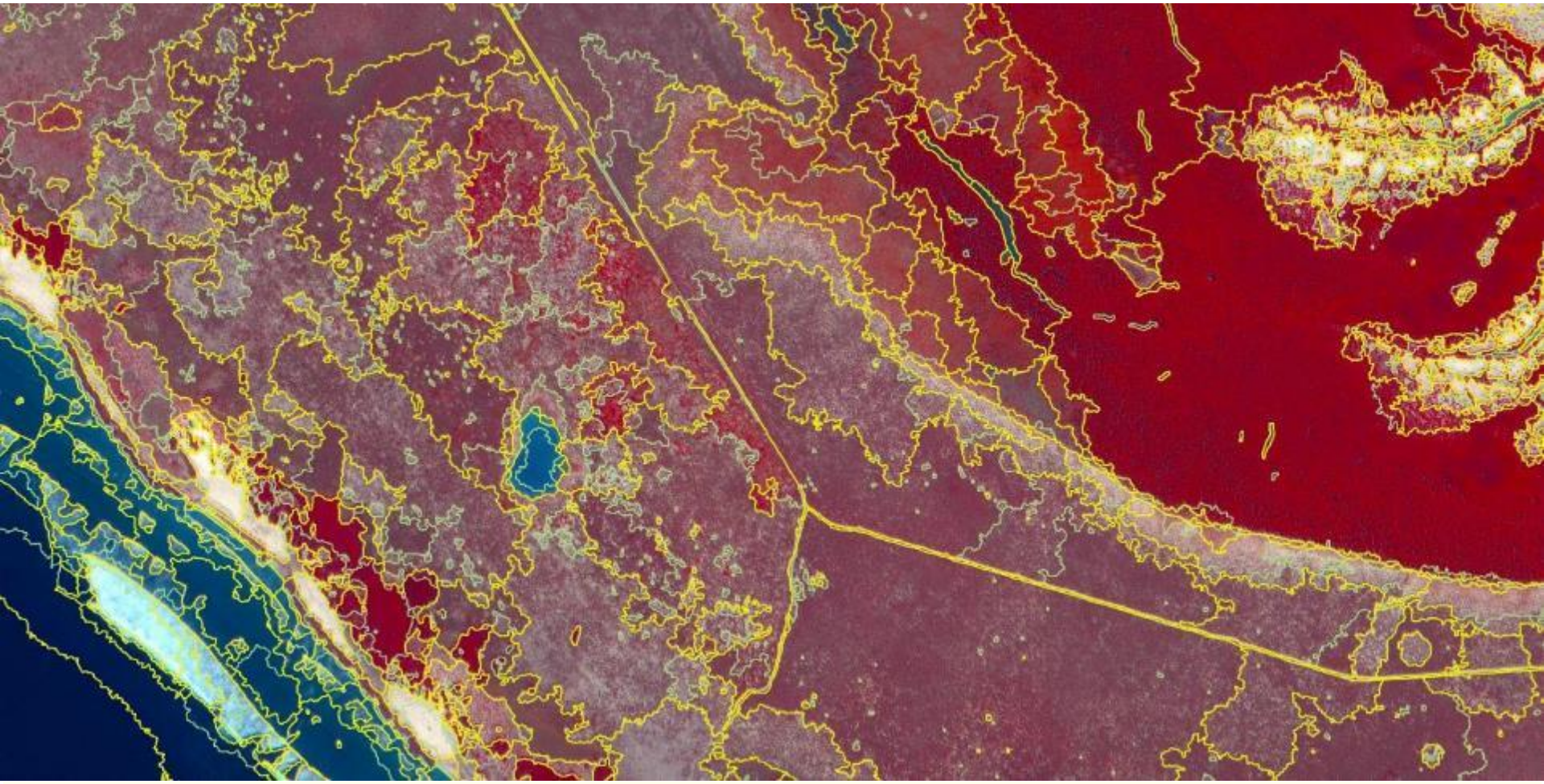
In order to find the regions to merge, for each small region and for all its neighbours, a degree of similarity is computed (based on colors) as well as a value of complexity of the polygon resulting from the merging of candidate regions.

It is then possible to choose the desired merge level (cut) in the pyramid that best fit the intended use.

HOW DOES THE SEGMENTATION SOFTWARE WORK ?

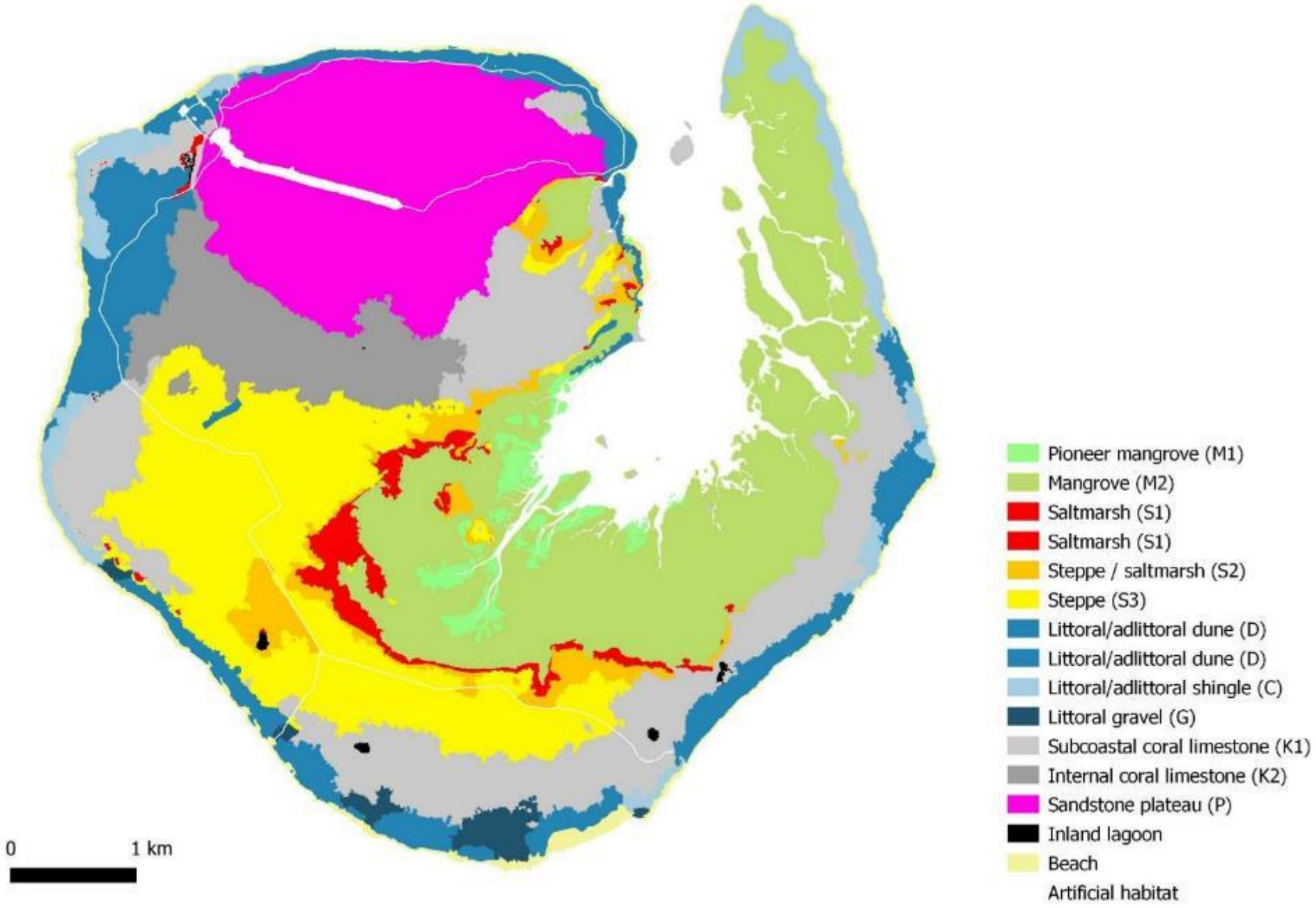


Segmentation at low level cut (C12) shows a good match with the series of vegetation, but less with elementary units of vegetation, because polygons most often correspond to dynamic mosaics of vegetation.
More detailled level cut (C8) appears sometimes complementary, but usually most irrelevant.



Purpose of mapping was a map of series and gesoseries (systems) of vegetation.
For this purpose, several types of vegetation are easily identifiable by photo-interpretation. Also each unambiguous C12 (or C8) polygon was directly informed by photo-interpretation in terms of series and systems.
All other polygons and system boundaries have been field verified and system boundaries modified as necessary.

Segmentation and pre-map of Europa at low level cup (C1) and more fine level (C2)



Map of vegetation systems (geoseries) of Europa Island

Paille-en-queue à brins rouges (*Phaethon rubicauda*)

Thank you for your attention

A big thank you to Alexandre Laubin (TAAF) for Europa's bird photos.

1 major serie in the system**: semi-arid coral sandstone adlittoral serie** [*Fico marmoratae-Euphorbio stenocladae sigmetum*] with « *Ficus marmorata-Euphorbia stenoclada* bush » as terminal vegetation.

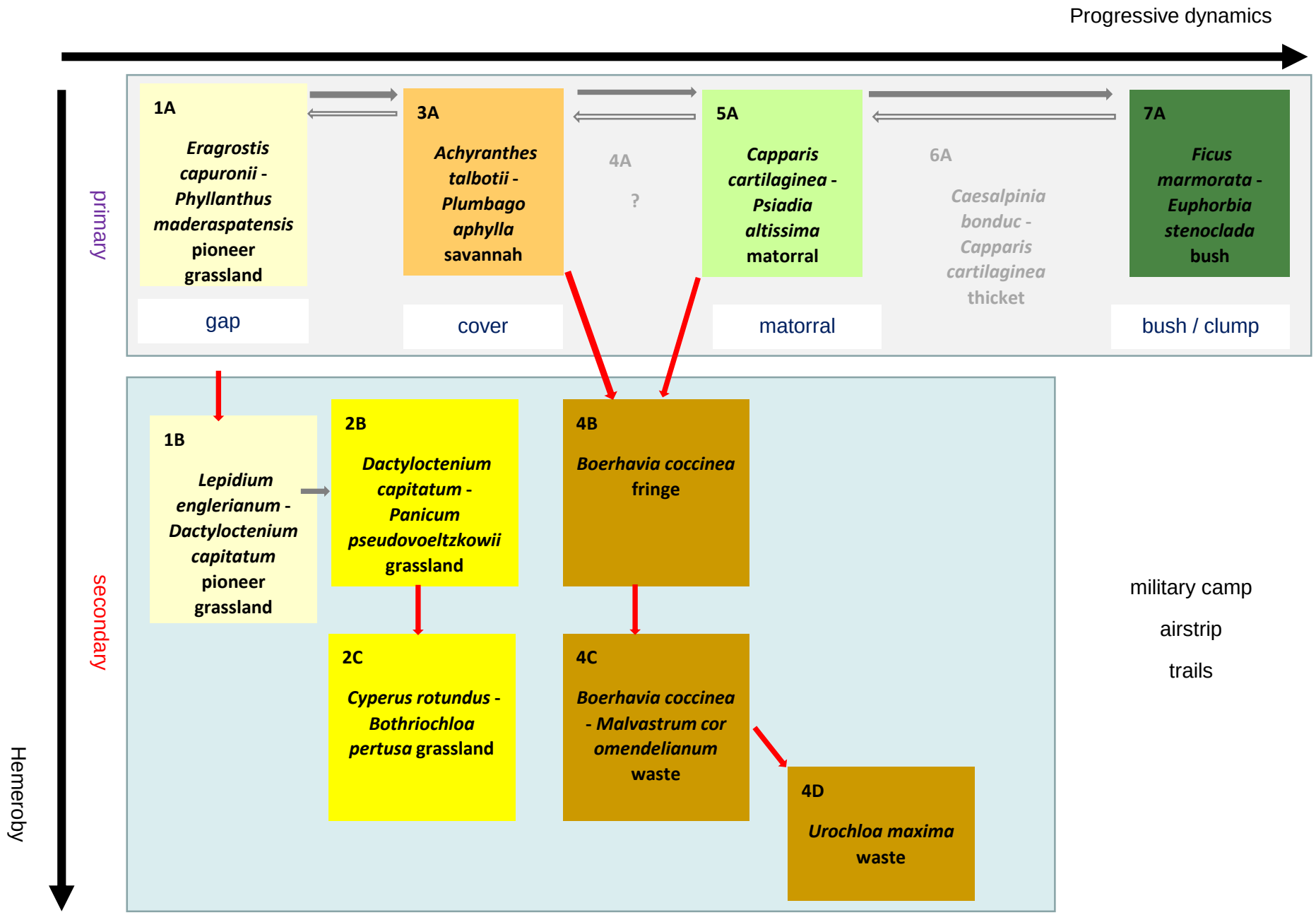
Sandstone plateau system on summit cay of Europa

2 structurant low trees in terminal vegetation

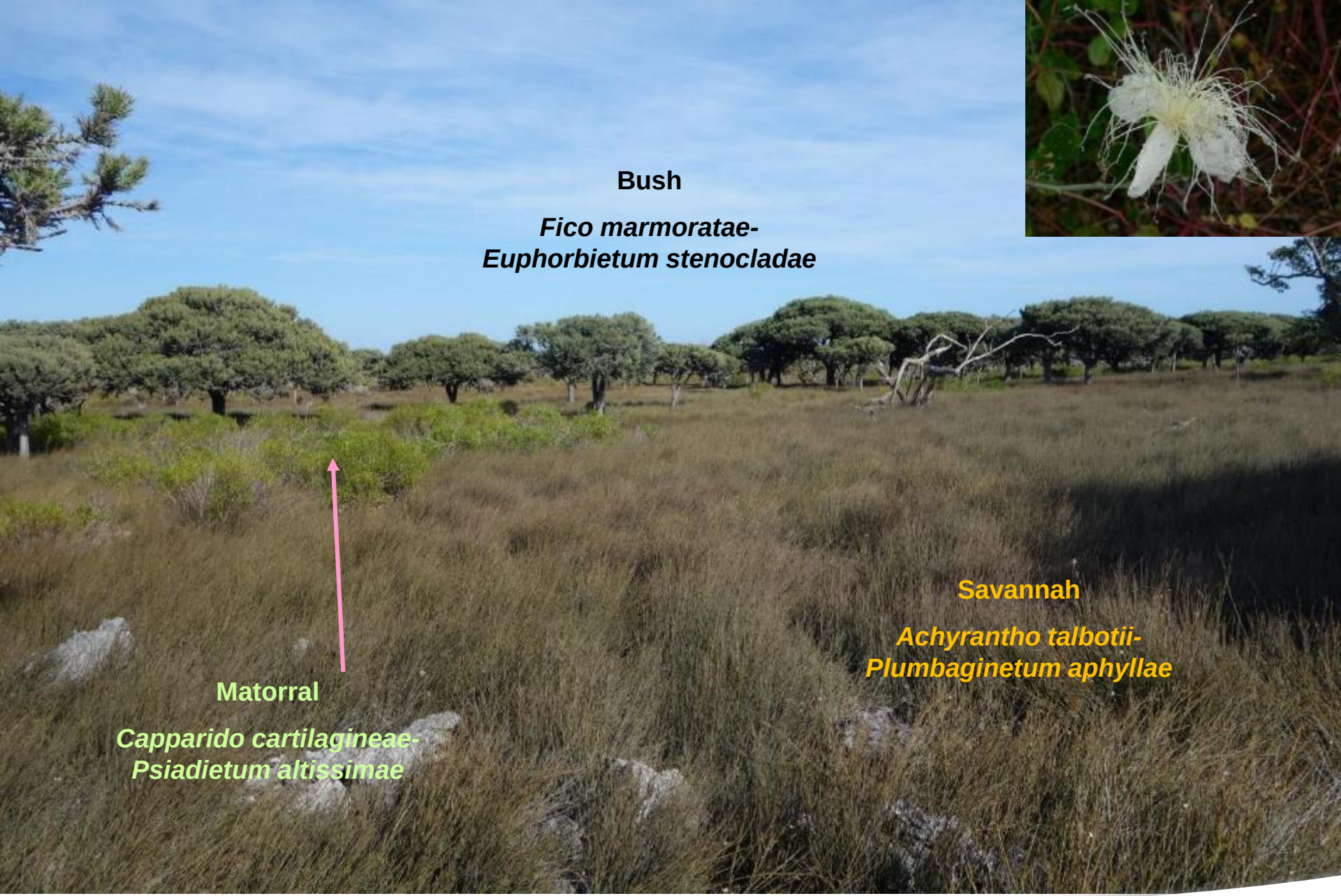
Sandstone plateau system on summit cay of Europa

2 structurant low trees in terminal vegetation

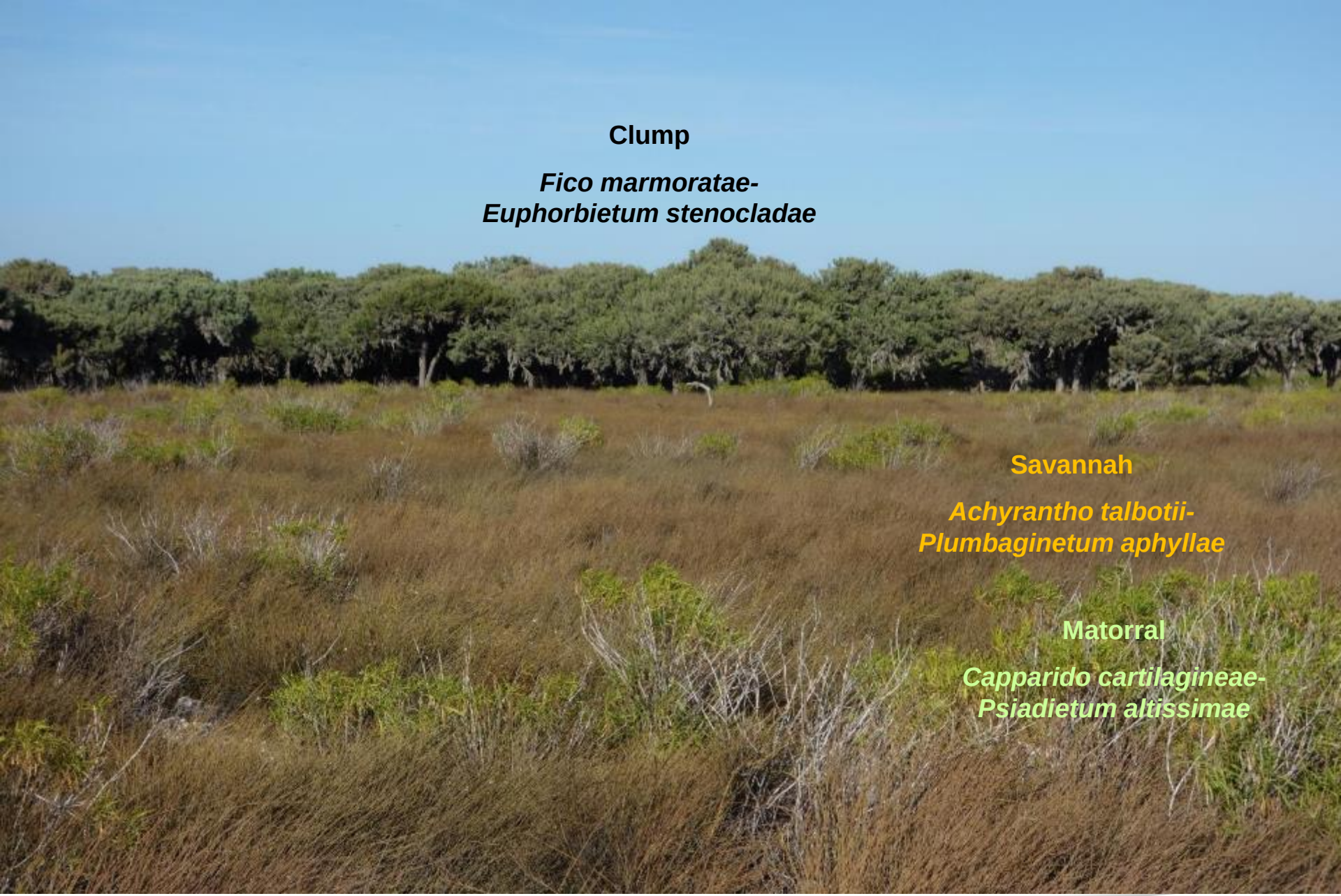
Sandstone plateau system on summit cay of Europa



Mozambican semi-arid coral sandstone adlittoral serie (*Fico marmoratae-Euphorbio stenocladae sigmetum*)



Fico marmoratae-Euphorbio stenocladae sigmetum: bush landcape



Fico marmoratae-Euphorbio stenocladae sigmetum: clump lanscape

Great Frigatebird [Frégate du Pacifique] (***Fregata minor***)

Final geobotanical map of vegetation systems of Europa island