Agenzia Spaziale Italiana

Il downstream nazionale tra presente e futuro:

un percorso condiviso con la comunità degli utenti

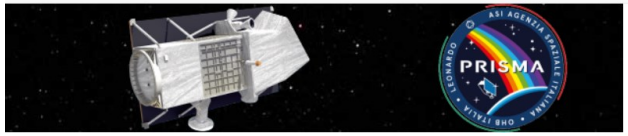
Impiego di dati PRISMA per la mappatura degli habitat forestali: primi risultati del progetto HyperEcos

Anna Barbati e Chiara Zabeo
(Università degli Studi della Tuscia – Dipartimento per l'Innovazione nei Sistemi Biologici, Agroalimentari e Forestali)

13-14
Dicembre 2023

Sede ASI
Via del politecnico snc,
00173 Roma (Italia)

UV VIS NIR SWIR



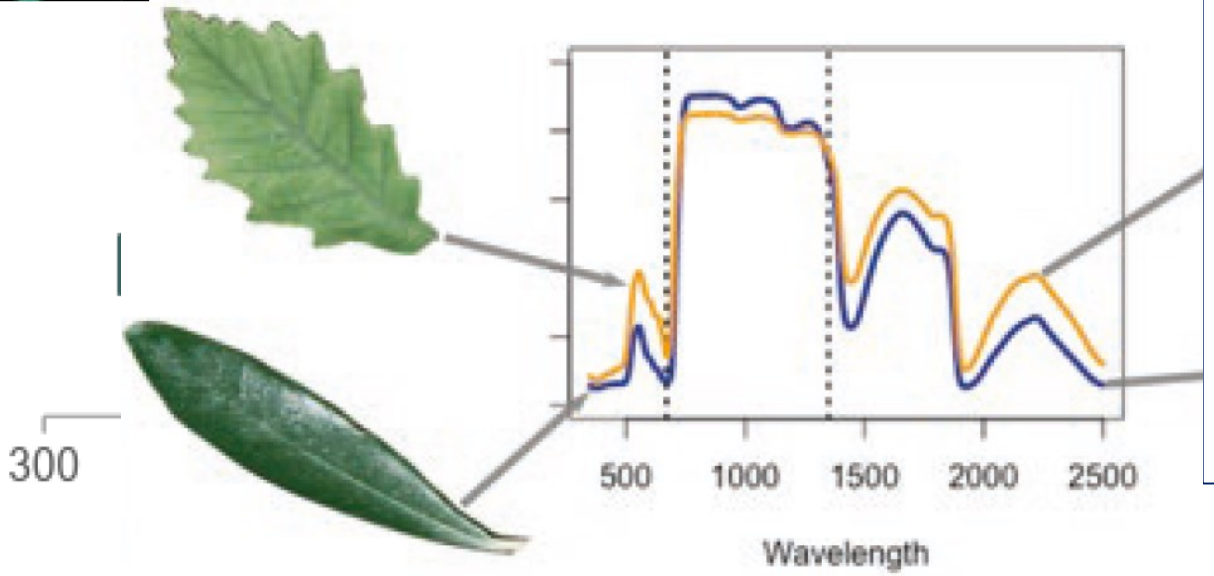
232 bands VIS_NIR_SWIR

Landsat-8

MODIS

Sentinel-3

Sentinel-2



Adapted from Cavender-Bares et al. 2017

Can PRISMA imaging spectroscopy offer a solution for the automated delineation of terrestrial habitat types?

HYPERECOS: HYPERspectral Prisma data for ECOSystem functions, habitats, and diversity

Project partners

Supporting partners

Test site: Castelporziano Natural Reserve (6000 ha ca)

Pastures

Mediterranean coniferous coastal dune forest

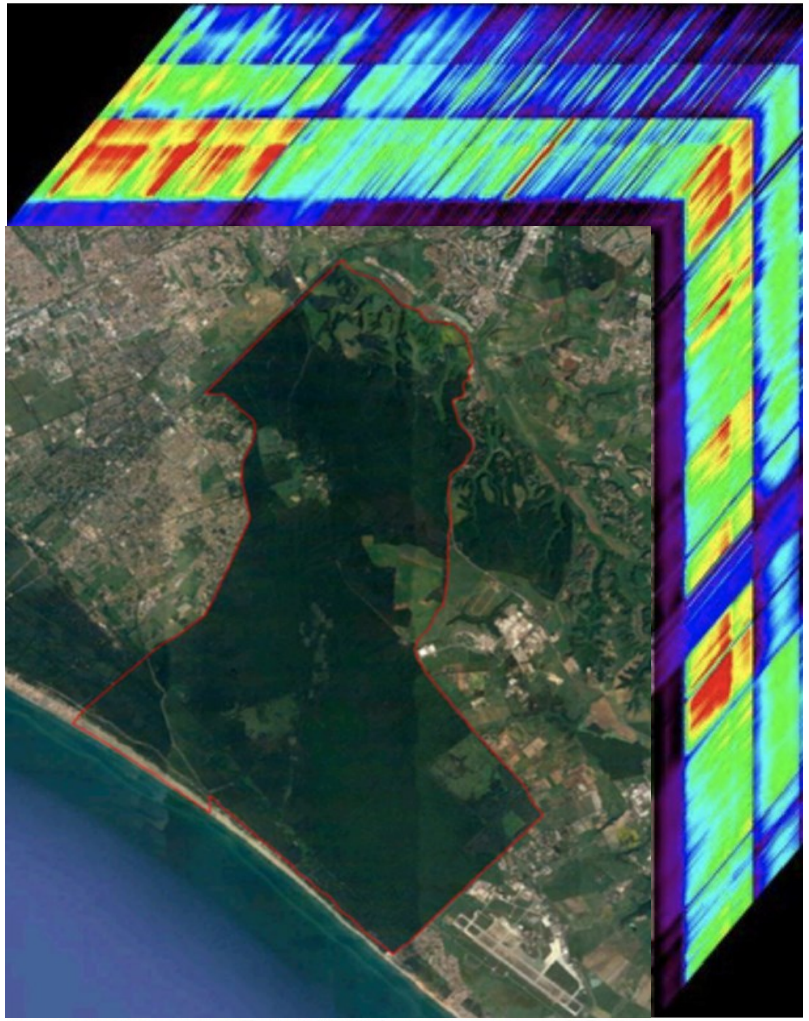
Southeastern sub-thermophilous Quercus

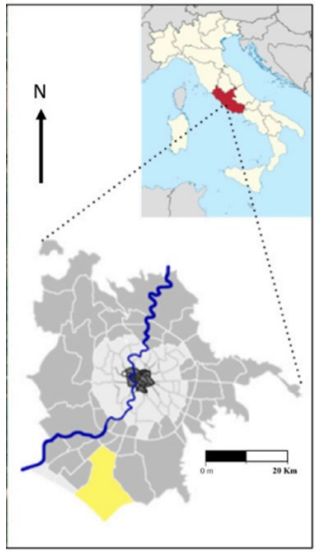
Quercus - Fraxinus - Carpinus betulus forest

Quercus ilex forest

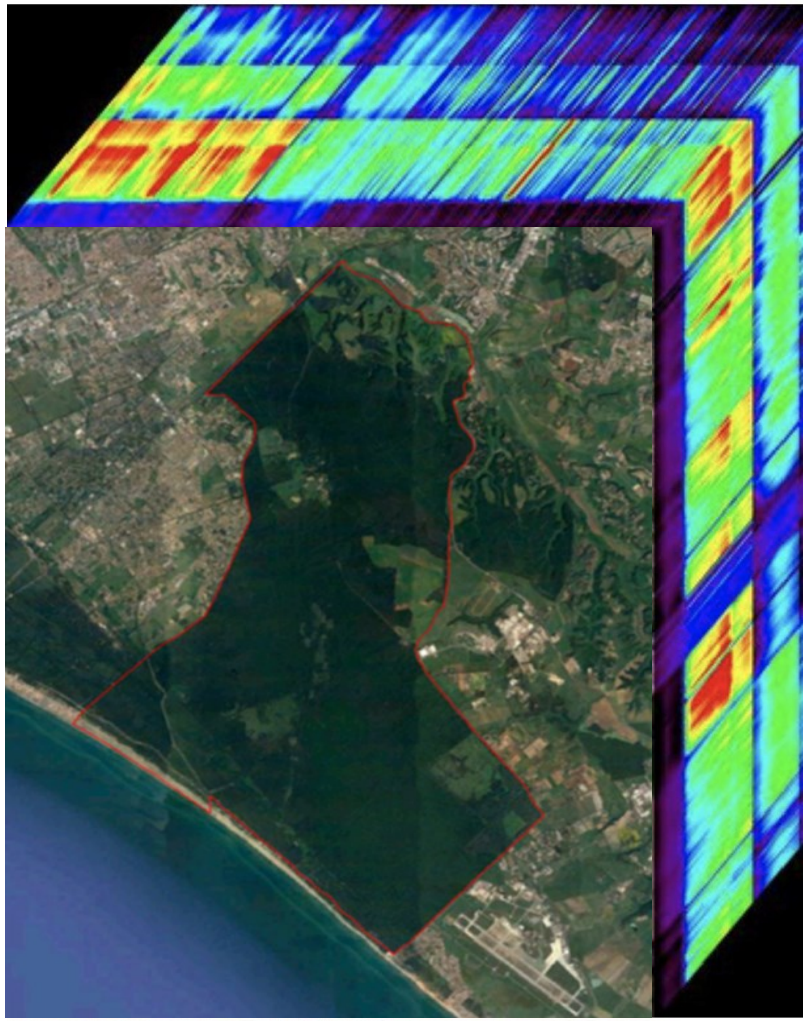
Quercus suber forest

Mediterranean maquis





HYPERECOS: HYPERspectral Prisma data for ECOSystem functions, habitats, and diversity



Develop methods to process PRISMA data for forest habitat mapping

Challenges

- ✓ does the time of image acquisition count?
- ✓ high dimensional datasets
- ✓ Making the most out of the hundreds through vegetation indices
- ✓ confusion between spectral similar habitat types (e.g. quercus dominated habitat and maquis)

Available PRISMA images

Castelporziano - usable PRISMA scenes		
2021	2022	2023
5	5	0

14/07/2022 (RGB: 50 30 15)

Land cover classes in Castelporziano

EUNIS 2021 codes
8 Forest Habitat types

Class code	Description
C1	Water
C2	Agricultural land
C3	Shrubland
C4	Areas in recolonization
C5	Special plantations
C6	Pastures
C7	Pastures with trees
C8	Beach
C9	Roads
C10	Urban areas
N1G	Mediterranean coniferous coastal dune forest
S51	Mediterranean maquis and arborescent matorral
T142	Mediterranean riparian Populus spp. forests
T195	Southeastern sub-thermophilous Quercus spp. forests
T19B6	Thermophilous Fraxinus spp. forests
T1E1	Quercus - Fraxinus - Carpinus betulus forest on eutrophic and mesotrophic soils
T211	Quercus suber forest
T212	Quercus ilex forest

Habitat mapping in Castelporziano

Challenge

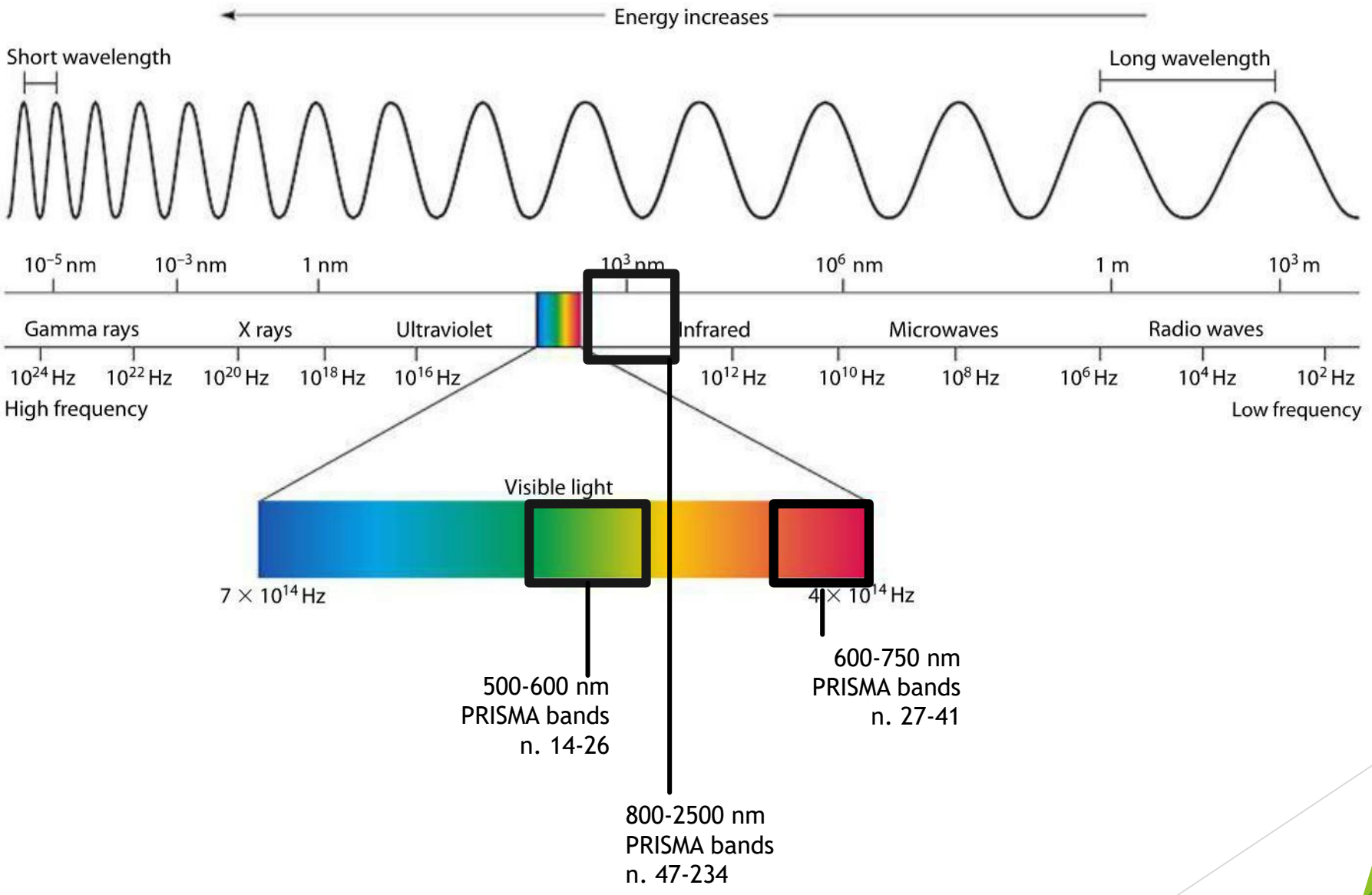
High number of land cover classes, some with high similarity → Increased difficulty in classification

How can PRISMA help solve this problem?

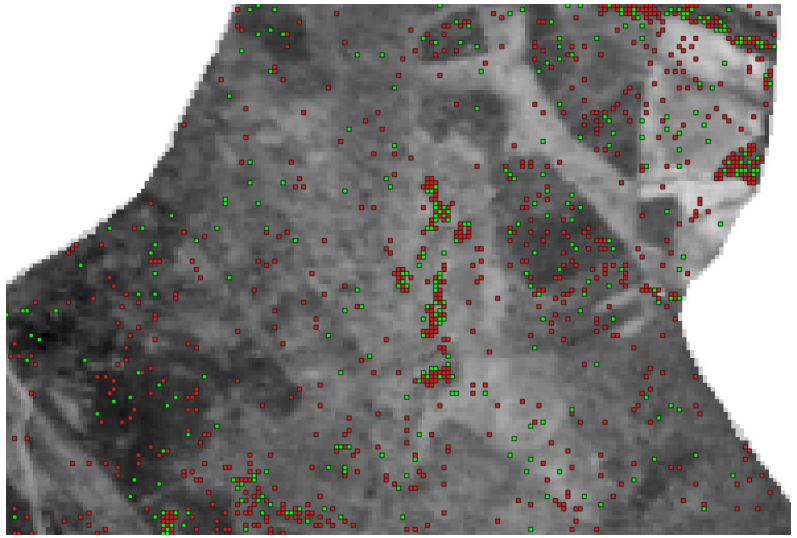
Higher spectral resolution, narrower bands → Increased discrimination rate

Higher spectral resolution, narrower bands → Higher numbers of computable spectral indices

Index	Formula (wavelenghts)	Formula (PRISMA bands)
Anthocyanin Reflectance Index (ARI)	(1/ρ550) - (1/ρ700)	(1/B11) - (1/B28)
Atmospheric resistant vegetation index (ARVI)	(ρ864 - [ρ660 – γ*(ρ470 - ρ660)]) / (ρ864 + [ρ660 - γ*(ρ470 - ρ660)])	(B44 - [B24 – 1.5*(B1 – B24)]) / (B44 + [B24 – 1.5* (B1 – B24)])
Cellulose Absorption Index (CAI)	100*[0.5*(ρ2032+ρ2213)−ρ2102]	100*[0.5*(B138+B161)-B147]
Carotenoid Reflectance Index (CRI)	(1/ρ510) - (1/ρ 550)	(1/B6) - (1/B11)
Enhanced Vegetation Index (EVI)	2.5 * (ρ864 – ρ660)/ (ρ864 + 6 * ρ660 – 7.5 * ρ487 + 1)	2.5 * (B44 – B24)/(B44 + 6 * B24 – 7.5 * B3 + 1)
Inverted Red-Edge Chlorophyll Index (IRECI)	[(ρ783 - ρ665)/ (ρ705/ ρ740)]	[(B36 – B24)/ (B29/ B32)]
Modified Chlorophyll Absorption Ratio Index (MCARI)	((ρ701 – ρ671) – 0.2 * (ρ701 – ρ549)) * (ρ701/ρ671)	((B28 – B25) – 0.2 * (B28 – B11)) * (B28 / B25)
Moisture Stress Index (MSI)	ρ1598/ρ823	B109/B39
Normalized Difference Infrared Index (NDII)	(ρ823 − ρ1649) / (ρ823 + ρ1649)	(B39 – B114)/ (B39 + B114)
Normalized Difference Lignin Index (NDLI)	[log(1/ρ1754)−log(1/ρ1680)]/]log(1/ρ1754)+log(1/ρ1680)]	[log(1/B123)−log(1/B117)]/[log(1/B123)+log (1/B117)]
Normalized Difference Vegetation Index (NDVI)	(ρ864 - ρ660) / (ρ864 + ρ660)	(B44 - B24)/(B44 + B24)
Normalized Difference Water Index (NDWI)	(ρ854−ρ1245)/(ρ860+ρ1240)	(B42−B84)/(B42+B84)
Optimized Soil-Adjusted Vegetation Index (OSAVI)	[(1+0.16) (ρ800 - ρ670)]/(ρ800 + ρ670 + 0.16)	[(1+0.16) (B38 – B25)] / (ρ800 + B25 + 0.16)
Photochemical Reflectance Index (PRI)	(ρ529 - ρ569)/(ρ529 + ρ569)	(B8 - B14)/(B8 + B14)
Plant Senescence Reflectance Index (PSRI)	(ρ681 - ρ498)/ρ752	(B26 – B4) / B33
Red Edge Normalized Difference Vegetation Index (RENDVI)	(ρ752 - ρ701)/(ρ752 + ρ701)	(B33 - B28)/(B33 + B28)
Red-Edge Position (REP)	(705 + 35*((ρ783 + ρ665)/2) - ρ705)/ (ρ740 - ρ705]	(705 + 35*((B36 + B24)/2) – B29)/ (B32 – ρ29]
Red-Green Ratio (RG)	ρ672/ ρ555	B25/ B12
Soil Adjusted Total Vegetation Index (SATVI)	(ρ1650 - ρ680) / (ρ1650 + ρ680 + L)	(B114 – B26) / (B114 + B26 + 0.5)
Simple Ratio (1060 and SR1640)	ρ1060/ ρ1640	B67/B113
Structure Insensitive Pigment Index (SIPI)	(ρ803 – ρ467)/(ρ803+ ρ681)	(B38 – B1)/(B38 + B26)
Simple ratio (SR; NIR/R)	ρ864 / ρ660	B44/ B24
Short Wave Infrared Ratio (SWIR)	(SWIR3/SWIR2) = ρ2105/ ρ1630	B148 / B112
Transformed Chlorophyll Absorption Ratio Index (TCARI)	3*[(ρ700 - ρ670) – 0.2*(ρ700 - ρ550) *(ρ700 /ρ670)]	3*[(B28 – B25) – 0.2*(B28 – B11) *(B28 / B25)]
Visible Atmospherically Resistant Index (VARI)	(ρ559 − ρ640)/(ρ559 + ρ640 − ρ467)	(B13 – B22)/(B13 + B22 – B1)
Visible Green Index (Vigreen)	(ρ559-ρ660)/(ρ559-ρ660)	(B12-B24)/(B12-B24)
Vogelmann Red Edge Index (VOG)	ρ742 / ρ722	B32/B30
Water Band Index (WBI)	ρ905/ρ972	B47/B58


Energy increases
Short wavelength
Long wavelength
10^{-5} nm
10^{-3} nm
1 nm
10^{3} nm
10^{6} nm
1 m
10^{3} m
Gamma rays
X rays
Ultraviolet
Infrared
Microwaves
Radio waves
10^{24} Hz
10^{22} Hz
10^{20} Hz
10^{18} Hz
10^{16} Hz
10^{12} Hz
10^{10} Hz
10^{8} Hz
10^{6} Hz
10^{4} Hz
10^{2} Hz
High frequency
Low frequency
Visible light
7×10^{14} Hz
4×10^{14} Hz
500-600 nm
PRISMA bands
n. 14-26
600-750 nm
PRISMA bands
n. 27-41
800-2500 nm
PRISMA bands
n. 47-234

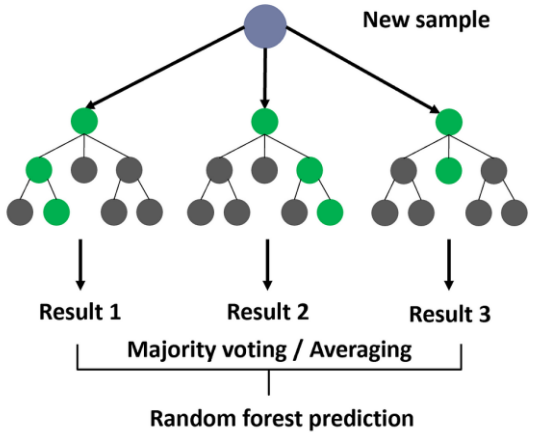
Supervised classification



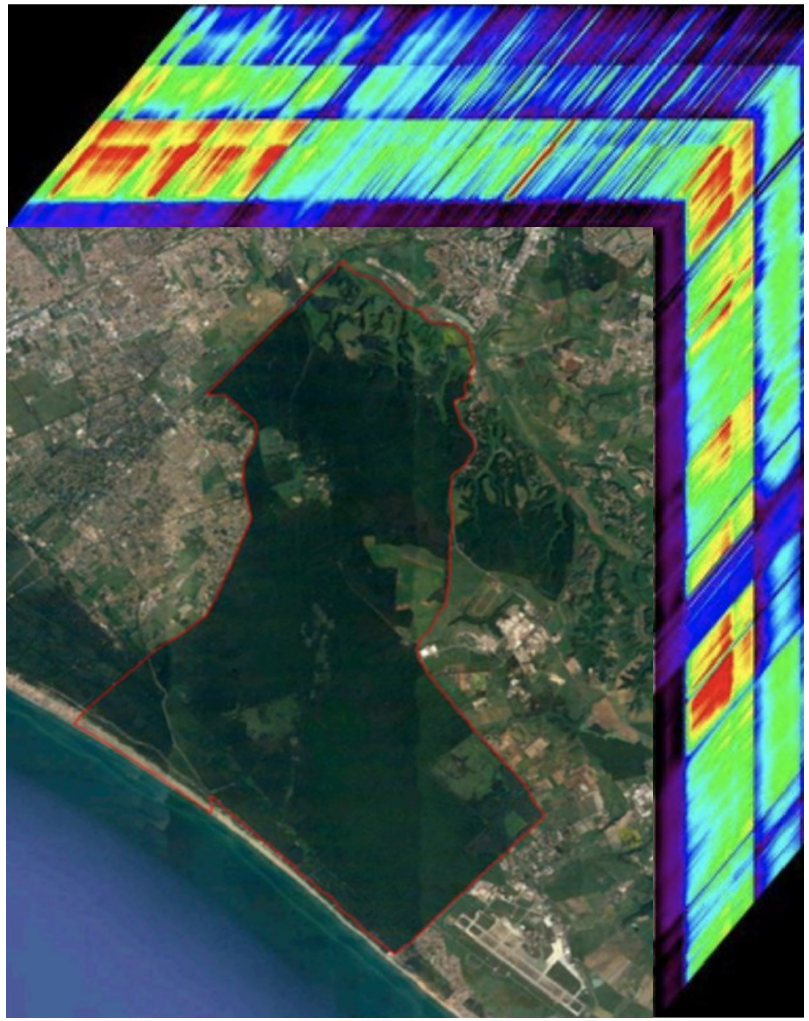
Reference land cover / habitat map

Random extraction of 250 pure pixels for each class; 70% for training and 30% for validation of the model

Random Forest



Classification workflow



Removal of noisy bands (bands 1-9; 104-111; 148-164; 227-234)
192 usable bands left

↓

Calculation of 28 spectral indexes; first classification

↓

Top 10 indeces by importance underwent multicollinearity analysis (Variable Inflation Factor)

↓

The 5-7 indexes were used for the final classification, with the addition of a Canopy Height Model

Classification results

	14_7_22	
N. of indexes used	8	
Overall accuracy	0.82	
Kappa value	0.81	
	User accuracy	Producer accuracy
C2 - Agricultural land	0.89	0.84
C3 - Shrubland	0.79	0.93
C4 - Areas in recolonization	0.97	0.95
C5 - Special plantations	0.75	0.85
C6 - Pastures	0.86	0.87
C7 - Pastures with trees	0.81	0.79
C8 - Beach	1.00	1.00
N1G - Mediterranean coniferous coastal dune forest	0.79	0.91
S51 - Mediterranean maquis and arborescent matorral	0.85	0.77
T195 - Southeastern sub-thermophilous Quercus spp. Forests	0.75	0.57
T19B6 - Thermophilous Fraxinus spp. Forests	0.83	0.93
T1E1 - Quercus - Fraxinus - Carpinus betulus forest on eutrophic and mesotrophic soils	0.70	0.65
T211 - Quercus suber forest	0.72	0.73
T212 - Quercus ilex and Q. rotundifolia forest	0.83	0.74

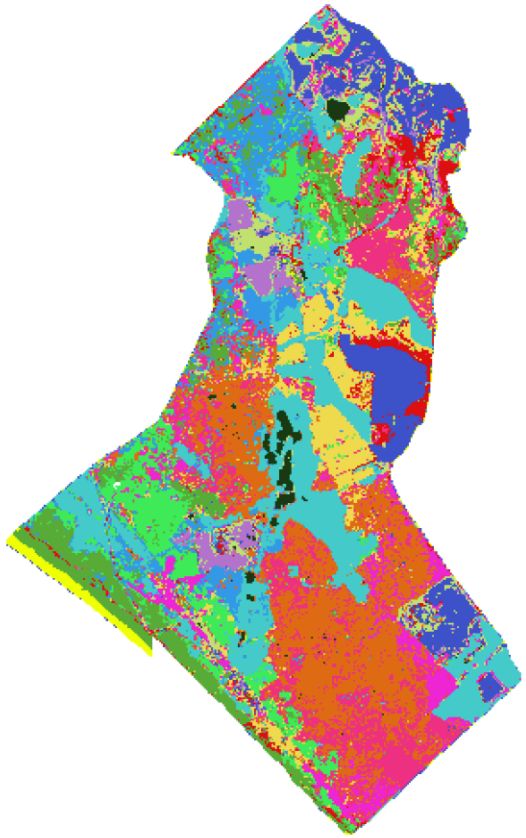
Index importance score	14/7/22	Mean Decrease Accuracy score
1st	CAI	88.10
2nd	TCARI	77.47
3rd	CHM_mean	72.11
4th	WBI	71.25
5th	CHM_stdev	62.63
6th	SWIR	59.49
7th	SATVI	55.55
8th	PRI	52.67

Confusion matrix

Reference

Prediction	C2	C3	C4	C5	C6	C7	C8	N1G	S51	T195	T19B6	T1E1	T211	T212
C2	63	0	0	0	4	2	0	1	0	1	0	0	0	0
C3	0	70	0	4	0	3	0	1	6	4	0	0	0	1
C4	0	0	71	0	0	2	0	0	0	0	0	0	0	0
C5	1	3	0	64	0	0	0	0	2	5	1	6	1	2
C6	8	0	0	0	65	3	0	0	0	0	0	0	0	0
C7	2	0	1	0	6	59	0	1	0	0	0	1	1	2
C8	0	0	0	0	0	0	75	0	0	0	0	0	0	0
N1G	0	1	1	1	0	4	0	68	0	1	0	1	8	1
S51	0	1	0	0	0	0	0	0	58	2	0	2	4	1
T195	1	0	1	0	0	0	0	0	0	43	0	9	0	3
T19B6	0	0	1	0	0	2	0	1	0	2	70	5	1	2
T1E1	0	0	0	4	0	0	0	1	1	13	2	49	0	0
T211	0	0	0	0	0	0	0	2	7	2	1	2	55	7
T212	0	0	0	2	0	0	0	0	1	2	1	0	5	55

PRISMA based land cover and habitat map



Castelporziano habitat classification

- C2: Agricultural land
- C3: Shrubland
- C4: Areas in recolonization
- C5: Special plantations
- C6: Pastures
- C7: Pastures with trees
- C8: Beach
- N1G: Mediterranean coniferous coastal dune forest
- S51: Mediterranean maquis and arborescent matorral
- T195: Southeastern sub-thermophilous Quercus spp. forests
- T19B6: Thermophilous Fraxinus spp. forest
- T1E1: Quercus - Fraxinus - Carpinus betulus forest on eutrophic and mesotrophic soils
- T211: Q. suber forest
- T212: Q. ilex and Q. rotundifolia forest

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