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Assessment of the EUNIS Forest habitat probability maps based on Article 17

Sander Mücher, Henk Kramer, Stephan Hennekens

and Sophie Condé

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Authors' affiliation:

Sander Mücher, Alterra (NL)
Henk Kramer, Alterra (NL)
Stephan Hennekens, Alterra (NL)
Sophie Condé, Muséum national d'Histoire naturelle (FR)

EEA project manager:

Markus Erhard, European Environment Agency (DK)

ETC/BD production support:

Muriel Vincent, Muséum national d'Histoire naturelle (FR)

Context:

The Topic Centre has prepared this Technical paper in collaboration with the European Environment Agency (EEA) under its 2015 work programmes as a contribution to the EEA's work on Ecosystem mapping and assessment.

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European Topic Centre on Biological Diversity
c/o Muséum national d'Histoire naturelle
57 rue Cuvier
75231 Paris cedex, France
Phone: + 33 1 40 79 38 70
E-mail: etc.biodiversity@mnhn.fr
Website: http://bd.eionet.europa.eu/

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1 Background and objectives

1.1 Background

In a former ETC/BD study (Mucher et al. 2015) a methodology was developed to model the spatial distribution of EUNIS forest habitat types based on vegetation relevés from the EVA database (European Vegetation Archive), the Copernicus High Resolution Layer (HRL) Forest and many other environmental data layers. This methodology resulted in the production of 24 EUNIS forest habitat probability maps at a 20 meter spatial resolution for the whole of Europe. In summary, the methodology consisted of a two-step approach. The first step consisted of a bottom-up approach for which the vegetation relevés were classified into the relevant EUNIS habitat classes, and 10 most relevant environmental data layers were selected, all of which were used as an input in MAXENT statistical modelling, resulting in habitat suitability maps at a 1km spatial resolution. In a second step, these habitat suitability maps were refined into habitat probability maps based on the actual land cover as derived from the Copernicus high resolution layer (HRL) Forest at a 20 meter spatial resolution. Both Tree Crown Density (TCD) and Forest Types (FTY: broadleaved and coniferous) were integrated in the methodology.

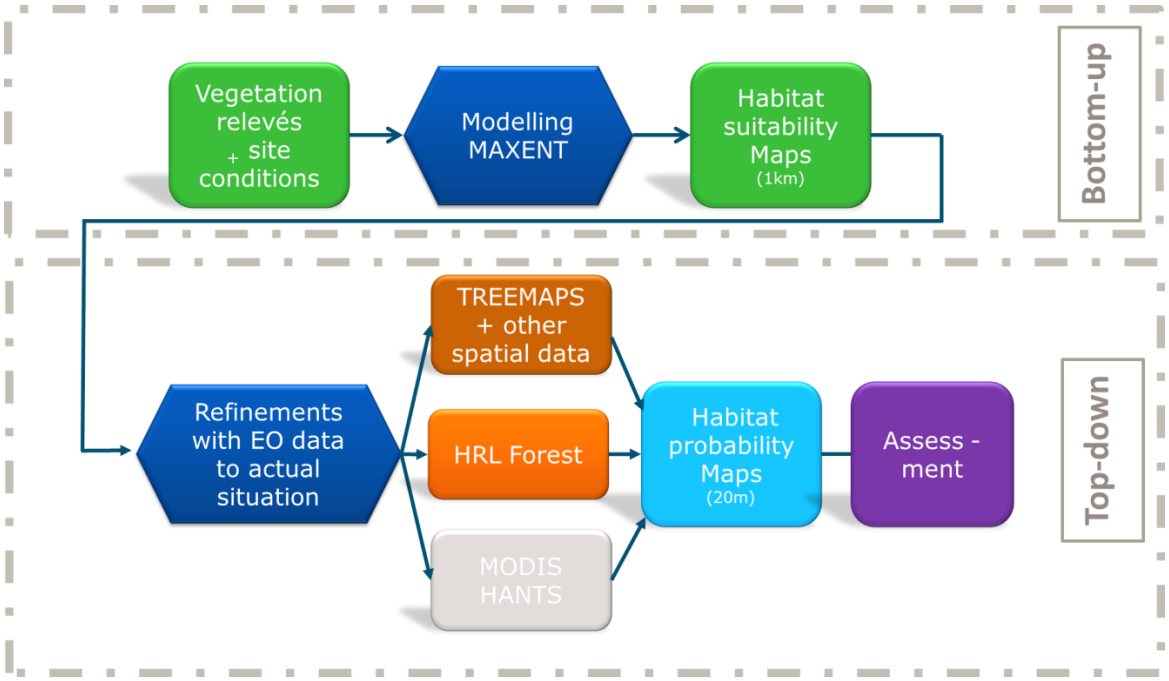


Figure 1 General workflow for the processing of EUNIS habitat probability maps. Starting with the exploitation of the European vegetation relevés in a bottom-up approach, succeeded by refinements into habitat probability maps based on amongst other actual land cover, in a top-down approach.

In the first study 15 of the 24 forest habitat probability maps were already assessed by ILE in detail for Slovakia based on national forest data and local environmental knowledge (Mücher et al. 2015). The independent assessment showed that the modelling approach described in the report is correct, well implemented and useful at the EU level. However, the assessment also showed the limitations, namely that due to the actual forest management the actual EUNIS forest habitats are often more limited in their extent, and in that sense the current forest habitat probability maps (HPM) are often showing their potential distribution within the current forests. Another limitation is the limited spatial resolution of some abiotic environmental layers such as the European soil database (scale 1: 1M).

Figure 2 provides the overall picture of the degree of correspondence between the modelled distribution of 14 EUNIS Forest habitat types at level 3 and their distribution according the Slovak forest dataset. For the general expression of the AUC values we used the same categories that were used for probability maps (i.e. AUC values 0.5-0.7 suggested low, 0.7-0.9 moderate and >0.9 high correspondence). The values of AUC indicate moderate correspondence for 8 forest habitat types (G3.2, G1.4, G3.1a, G3.E, G1.7, G3.4b, G3.1b, G1.A) and poor correspondence for 6 forest habitat types G1.1, G1.2, G1.5, G1.6a, G1.6b, G1.8, G3.4a). We did not record any perfect correspondence, although G3.2 was very close to the threshold.

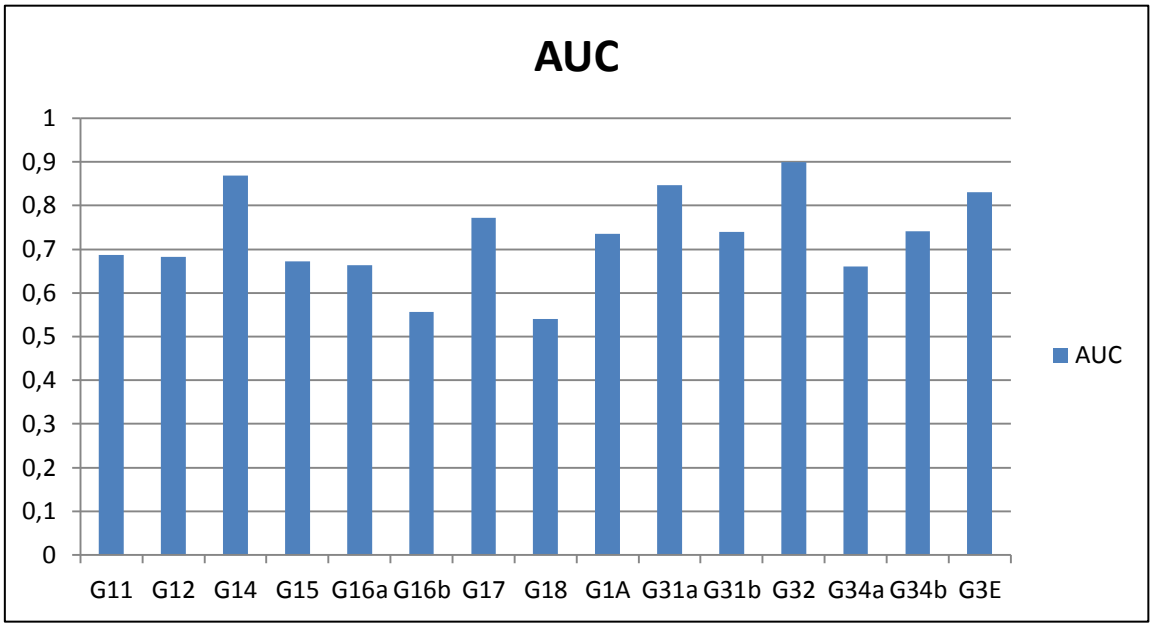


Figure 2 Area Under Curve (AUC) as a performance indicator for the studied EUNIS Forest habitat types (European wide habitat probability maps versus Slovakian national forest dataset).

To better understand the added value of the produced EUNIS forest habitat probability maps it was recognized that it would be wise to make a European wide assessment. This resulted in the idea to make a comparison between the Article 17 database which contains amongst others a European 10 km grid with the presence and absence of all Annex I habitat types – and the produced EUNIS Forest habitat probability maps.

The assessment report is part of the assignment of Alterra for the European Topic Centre Biological Diversity (ETC/BD). The European Topic Centres (ETCs) are international consortia brought together to support the European Environment Agency (EEA) in its mandate on environmental information. ETCs are according to the EEA regulation and in practice, an important instrument in supporting the EEA through the execution of sizeable, continuous, well-defined tasks with the involvement of member countries. In particular ETCs support EEA data centres for the issues related to air, climate change, water, biodiversity and land use and may provide help to EEA in supporting other data centres coordinated by Eurostat and JRC. The ETC/BD is an international consortium working with the European Environment Agency under a framework partnership agreement. More information about ETC/BD can be found at: http://bd.eionet.europa.eu/.

1.2 Objectives

As a contribution to the task 1.7.5 C Ecosystem mapping and assessment, from the 2015 ETC/BD Action Plan the main objective is the assessment of the produced EUNIS Forest habitat probability maps based on Article 17 dataset.
The table below lists the 24 EUNIS habitat types for which the probability distribution maps will be compared with the Article 17 database.

Table 1 Short summary of EUNIS forest habitat types at level 3

Nr.	Code	Name EUNIS forest habitat type
1	B1.7	Coastal dune woodland* [Coastal dune woods]
2	G1.1	Temperate and boreal softwood riparian woodland* [Riparian and gallery woodland, with dominant [Alnus], [Betula], [Populus] or [Salix]]
3	G1.2	Temperate and boreal hardwood riparian woodland* [Mixed riparian floodplain and gallery woodland]
4	G1.3	Mediterranean and Macaronesian riparian woodland* [Mediterranean riparian woodland]
5	G1.4	Broadleaved swamp woodland on non-acid peat* [Broadleaved swamp woodland not on acid peat]
6	G1.5	Broadleaved swamp woodland on acid peat* [Broadleaved swamp woodland on acid peat]
7	G1.6a	Fagus woodland on non-acid soils
8	G1.6b	Fagus woodland on acid soils
9	G1.7	Thermophilous deciduous woodland
10	G1.8	Acidophilous Quercus woodland* [Acidophilous [Quercus]-dominated woodland]
11	G1.9a	Mountain Betula and Populus tremula woodlands on mineral soils
12	G1.A	Mesotrophic and eutrophic deciduous woodland, not dominated by Fagus* [Meso- and eutrophic [Quercus], [Carpinus], [Fraxinus], [Acer], [Tilia], [Ulmus] and related woodland]
13	G2.1	Mediterranean evergreen Quercus woodland* [Mediterranean evergreen [Quercus] woodland]
14	G2.4	Olea oleaster-Ceratonia siliqua woodland* [Olea europaea] - [Ceratonia siliqua] woodland]
15	G2.6	Ilex aquifolium woodland* [[Ilex aquifolium] woods]
16	G3.1a	Temperate mountain Picea woodland
17	G3.1b	Temperate mountain Abies woodland
18	G3.2	Temperate subalpine Larix-Pinus woodland* [Alpine [Larix] - [Pinus cembra] woodland]
19	G3.4a	Temperate continental Pinus sylvestris woodland
20	G3.4b	Temperate and submediterranean montane Pinus sylvestris-nigra woodland
21	G3.7	Mediterranean lowland to submontane Pinus woodland* [Lowland to montane mediterranean [Pinus] woodland (excluding [Pinus nigra])]
22	G3.9a	Taxus baccata woodland
23	G3.9b	Mediterranean Cupressaceae woodland
24	G3.E	Temperate bog conifer woodland* [Nemoral bog conifer woodland]

The next table provides the cross-walk between the EUNIS forest habitat types with the Annex I habitat types. This cross-walk is based on information from eunis.eea.europa.eu/habitats and has been revised. The relationship between EUNIS and Annex I habitats are not always straightforward (one to many and many to one relationships, in addition to larger or smaller overlaps) and therefore the table below should be considered as a first assessment and is subject for improvements. Also note that any different crosswalk can have a large impact on the result of the validation. A future solution is to base these cross walks on basis on their relation with phytosociological associations.

Table 2 Crosswalk between EUNIS forest habitats and Annex I habitats

Nr	EUNIS code	EUNIS name	Annex I code	Annex 1 Name
1	B1.7	Coastal dune woodland* [Coastal dune woods]	?	
2	G1.1	Temperate and boreal softwood riparian woodland* [Riparian and gallery woodland, with dominant [Alnus], [Betula], [Populus] or [Salix]]	91E0	91E0 * Alluvial forests with Alnus glutinosa and Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae)
			92A0	92A0 Salix alba and Populus alba galleries
3	G1.2	Temperate and boreal hardwood riparian woodland* [Mixed riparian floodplain and gallery woodland]	91E0	91E0 * Alluvial forests with Alnus glutinosa and Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae)
			91F0	91F0 Riparian mixed forests of Quercus robur, Ulmus laevis and Ulmus minor, Fraxinus excelsior or Fraxinus angustifolia, along the great rivers (Ulmenion minoris)
4	G1.3	Mediterranean and Macaronesian riparian woodland* [Mediterranean riparian woodland]	92A0	92A0 Salix alba and Populus alba galleries
			92C0	92C0 Platanus orientalis and Liquidambar orientalis woods (Plantanion orientalis)
5	G1.4	Broadleaved swamp woodland on non-acid peat* [Broadleaved swamp woodland not on acid peat]	?	
6	G1.5	Broadleaved swamp woodland on acid peat* [Broadleaved swamp woodland on acid peat]	9080	9080 *Fennoscandian deciduous swamp woods
			91D0	91D0 * Bog woodland
7	G1.6[a]	Fagus woodland on non-acid soils	9270	'9270 Hellenic beech forests with Abies borisii-regis
			9130	9130 Asperulo-Fagetum beech forests
			9140	9140 Medio-European subalpine beech woods with Acer and Rumex arifolius
			9150	9150 Medio-European limestone beech forests of the Cephalanthero-Fagion
			91K0	91K0 Illyrian Fagus sylvatica forests (Aremonio-Fagion)
			91S0	91S0 *Western Pontic beech forests
			91V0	91V0 Dacian Beech forests (Symphyto-Fagion)
			91W0	91W0 Moesian beech forests
			91X0	91X0 *Dobrogean Beech forests
			9210	
8	G1.6b	Fagus woodland on acid soils	9110	9110 Luzulo-Fagetum beech forests
			9120	9120 Atlantic acidophilous beech forests with Ilex and sometimes also Taxus in the shrublayer (Quercinion robori-petraeae or Ilici-Fagenion)
9	G1.7	Thermophilous deciduous woodland	91AA	91AA *Eastern white oak woods
			91B0	91B0 Thermophilous Fraxinus angustifolia woods
			91H0	91H0 * Pannonian woods with Quercus pubescens
			91I0	91I0 * Euro-Siberian steppic woods with Quercus spp.

			91M0	91M0 Pannonian-Balkanic turkey oak-sessile oak forests
			91N0	91N0 *Pannonic inland sand dune thicket (Junipero-Populetum albae)
			91Z0	91Z0 Moesian Silver lime woods
			9230	9230 Galicio-Portuguese oak woods with Quercus robur and Quercus pyrenaica
			9240	9240 Quercus faginea and Quercus canariensis Iberian woods
			9250	9250 Quercus trojana woods
			9260	9260 Castanea sativa woods
			9310	9310 Aegean Quercus brachyphylla forests
			9350	9350 Quercus macrolepis forests
10	G1.8	Acidophilous Quercus woodland* [Acidophilous [Quercus]-dominated woodland]	9190	9190 Old acidophilous oak woods with Quercus robur on sandy plains
			91A0	91A0 Old sessile oak woods with Ilex and Blechnum in the British Isles
11	G1.9[a]	Mountain Betula and Populus tremula woodlands on mineral soils	9010	'9010 * Western Taïga
			9040	9040 Nordic subalpine/subarctic forests with Betula pubescens ssp. Czerepanovii
12	G1.A	Mesotrophic and eutrophic deciduous woodland, not dominated by Fagus* [Meso- and eutrophic [Quercus], [Carpinus], [Fraxinus], [Acer], [Tilia], [Ulmus] and related woodland]	9020	'9020 * Fennoscandian hemiboreal natural old broad-leaved deciduous forests (Quercus, Tilia, Acer, Fraxinus or Ulmus) rich in epiphytes
			9160	'9160 Sub-Atlantic and medio-European oak or oakhornbeam forests of the Carpinion betuli
			9170	'9170 Galio-Carpinetum oak-hornbeam forests
			9180	9180 * Tilio-Acerion forests of slopes, screes and ravines
			91G0	91G0 * Pannonic woods with Quercus petraea and Carpinus betulus
			91L0	91L0 Illyrian oak –hornbeam forests (Erythronio-Carpinion)
			91Y0	91Y0 Dacian oak & hornbeam forests
13	G2.1	Mediterranean evergreen Quercus woodland* [Mediterranean evergreen [Quercus] woodland]	9330	9330 Quercus suber forests
			9340	9340 Quercus ilex and Quercus rotundifolia forests
14	G2.4	Olea oleaster-Ceratonia siliqua woodland* [Olea europaea] - [Ceratonia siliqua] woodland]	9320	'9320 Olea and Ceratonia forests
15	G2.6	Ilex aquifolium woodland* [[Ilex aquifolium] woods]	9380	'9380 Forests of Ilex aquifolium
16	G3.1[a]	Temperate mountain Picea woodland	9410	9410 Acidophilous Picea forests of the montane to alpine levels (Vaccinio-Piceetea)
17	G3.1b	Temperate mountain Abies woodland	91BA	91BA Moesian silver fir forests
			91P0	91P0 Holy Cross fir forests (Abietetum polonicum)
			9510	9510 * Southern Apennine Abies alba
18	G3.2	Temperate subalpine Larix-Pinus woodland* [Alpine [Larix] - [Pinus cembra] woodland]	9420	'9420 Alpine Larix decidua and/or Pinus cembra forests

19	G3.4[a]	Temperate continental Pinus sylvestris woodland	91CA	91CA Rhodopide and Balkan Range Scots pine forests
			91Q0	91Q0 Western Carpathian calcicolous Pinus sylvestris forests
			91R0	91R0 Dinaric dolomite Scots pine forests (Genisto januensis-Pinetum)
			91T0	91T0 Central European lichen Scots pine forests
20	G3.4b	Temperate and submediterranean montane Pinus sylvestris-nigra woodland	91CA	91CA Rhodopide and Balkan Range Scots pine forests
			91Q0	91Q0 Western Carpathian calcicolous Pinus sylvestris forests
			91R0	91R0 Dinaric dolomite Scots pine forests (Genisto januensis-Pinetum)
			91T0	91T0 Central European lichen Scots pine forests
21	G3.7	Mediterranean lowland to submontane Pinus woodland* [Lowland to montane mediterranean [Pinus] woodland (excluding [Pinus nigra])]	2270	'2270 * Wooded dunes with Pinus pinea and/or Pinus pinaster
			9540	9540 Mediterranean pine forests with endemic Mesogean pines
22	G3.9[a]	Taxus baccata woodland	91J0	91J0 * Taxus baccata woods of the British Isles
			9210	9210 * Apennine beech forests with Taxus and Ilex
			9580	9580 * Mediterranean Taxus baccata woods
23	G3.9b	Mediterranean Cupressaceae woodland	?	
24	G3.E	Temperate bog conifer woodland* [Nemoral bog conifer woodland]	91D0	91D0 * Bog woodland

2 Assessment of the EUNIS Forest habitat probability maps based on Article 17

In this assessment, each EUNIS forest habitat type is presented below by three maps.

- The first map is our modelled EUNIS forest habitat probability map indicating with a percentage that the specific EUNIS habitat really occurs with a 20 m grid cell (according to our method based on amongst other in situ vegetation relevés).

- The second map is an aggregation of the first map to a 10 km grid cell using the counts of 20 m grid cells that have a probability greater than 0 for that specific habitat type in a specific 10 km grid. In each 10 km grid cell 500 x 500 20 m grid cells fit (% presence = count/250000). The second map is easier to compare with the third map (and is limited to EU member states).

- The third map is the reference map based on the Article 17 database (obtained through the EU member states) with each time one or more Natura 2000 habitats that are affiliated with the selected EUNIS habitat type (see also Table 2).

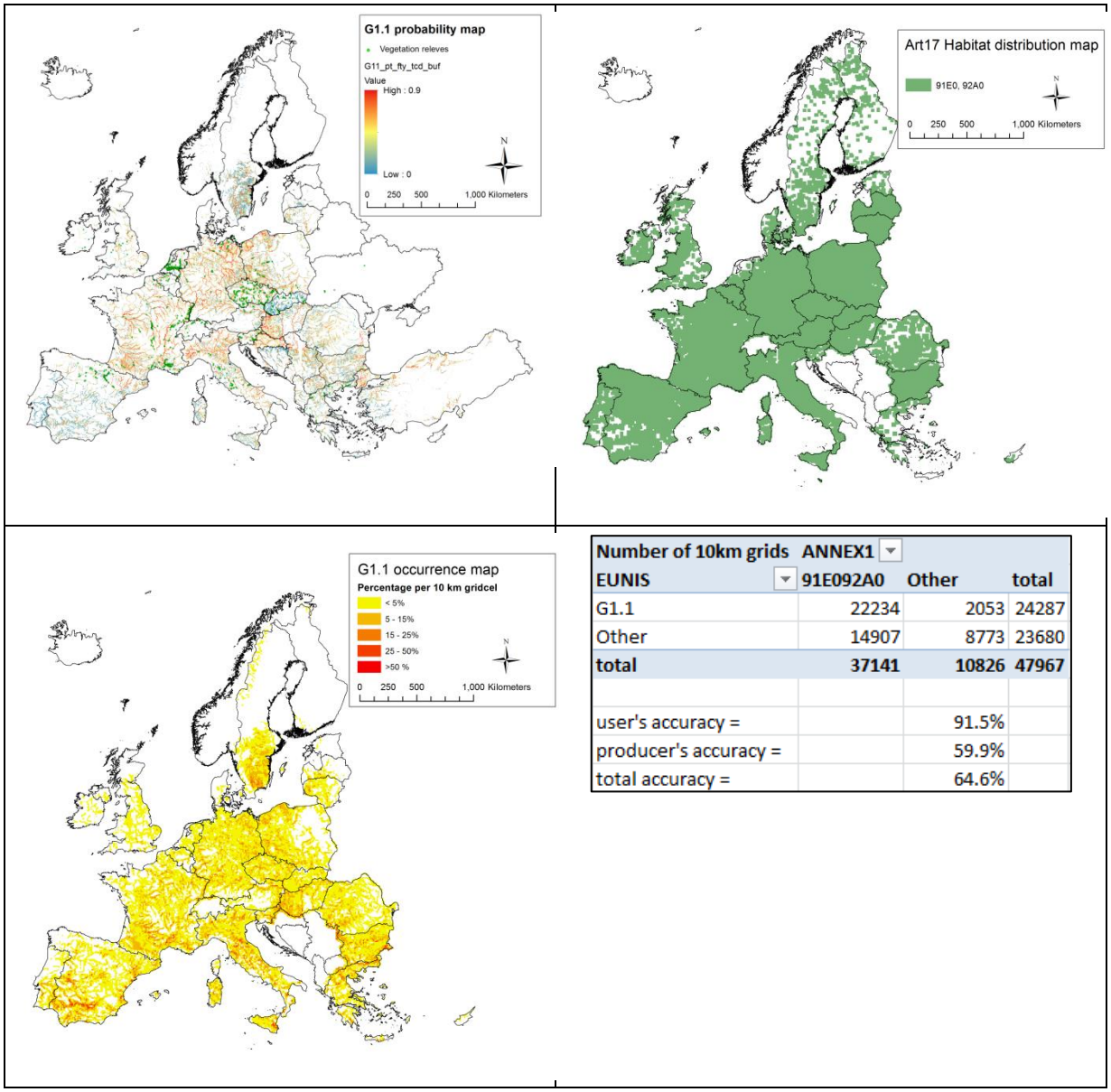
This followed by a table with a compact accuracy assessment (error matrix) on the presence or absence of a specific habitat type with the 10km grid cells. The accuracy assessment is using the Art 17 habitat maps as a reference for the assessment of the modelled EUNIS habitat types.

- The user accuracy indicates for example for G1.1 riparian woodland that 91.5% of the modelled EUNIS habitat type is really occurring in the specific grid cells.

- The producer's accuracy is indicating how much of the Article 17 grid cells are identified by our modelled EUNIS habitat classes. In most cases the producer's accuracy is lower than the user's accuracy, indicating that our models do not identify every grid cell where the habitat occurs according to Art 17.

- The total accuracy is determined by the presence as well as by the absence of the habitat type. The overall accuracy is seen as poor if % is lower than 60%, as reasonable as percentage is higher than 60%, as good as the percentage is higher than 70% and as excellent if percentage is higher than 80%.

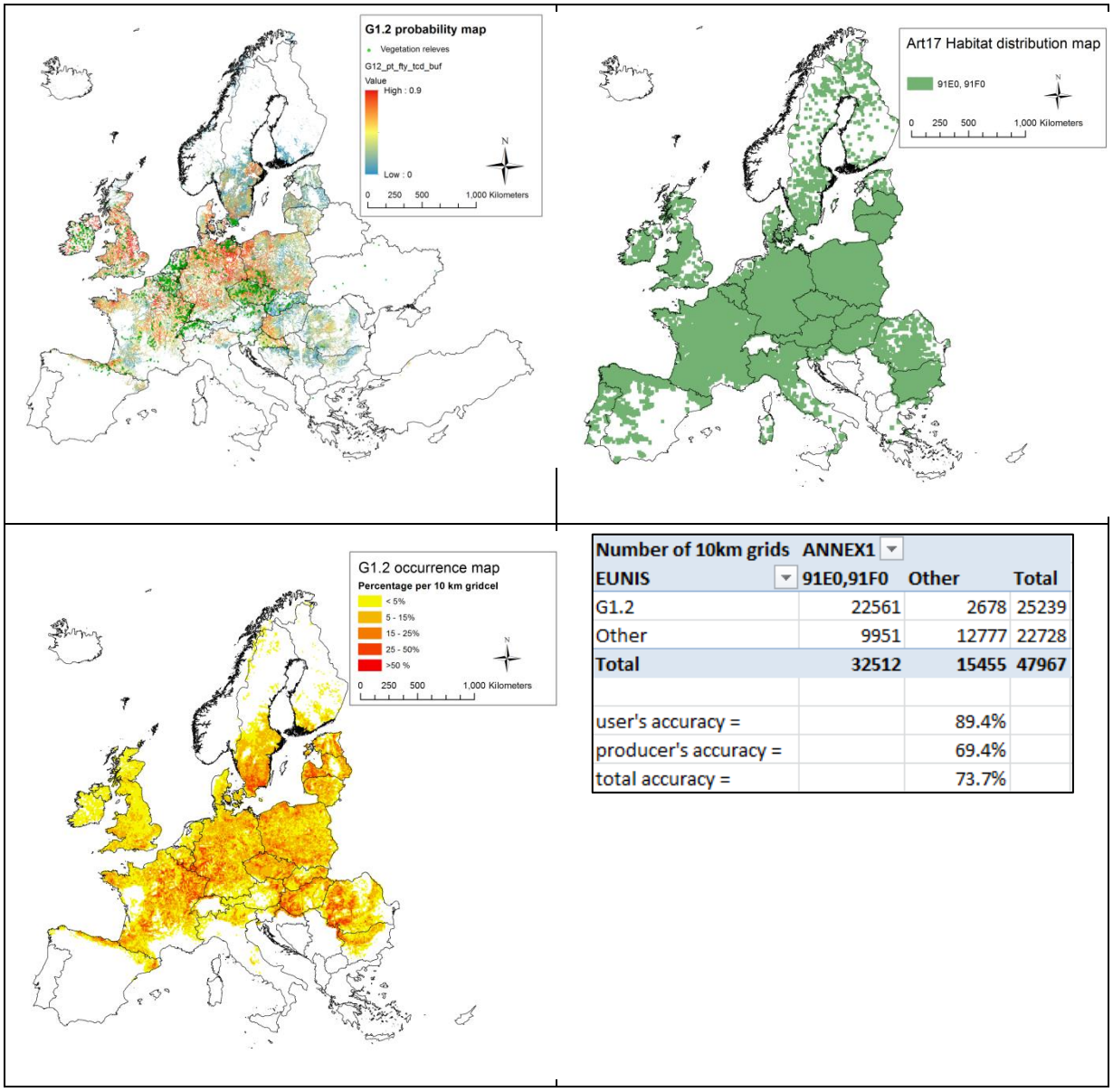
G1.1 Temperate and boreal softwood riparian woodland* [Riparian and gallery woodland, with dominant [Alnus], [Betula], [Populus] or [Salix]]



Number of 10km grids	ANNEX1		
EUNIS	91E092A0	Other	total
G1.1	22234	2053	24287
Other	14907	8773	23680
total	**37141**	**10826**	**47967**
user's accuracy =		91.5%	
producer's accuracy =		59.9%	
total accuracy =		64.6%	

Map 1 Assessment of the 20 m resolution EUNIS forest habitat probability map G1.1 'Temperate and boreal softwood riparian woodland' (above left), aggregated to a 10 km grid with % modelled presence (below left) compared with Article 17 Natura 2000 database with the same forest habitat type (91E0 and 92 A0). Followed by an error matrix (EUNIS forest habitat probability map versus Art 17 forest habitat type) based on the presence or absence of the specific habitat type with the 10km grid cells.

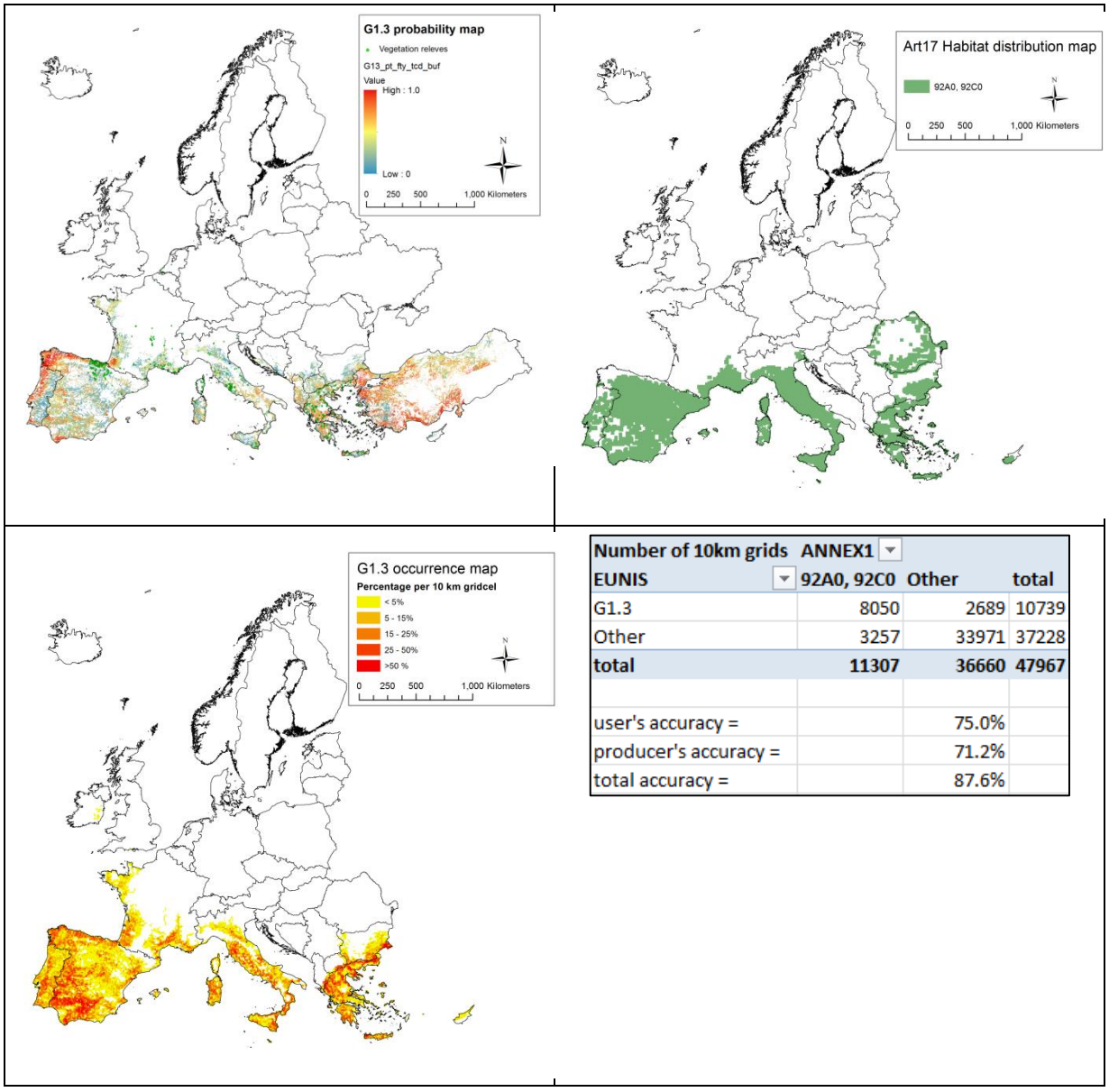
G1.2 Temperate and boreal hardwood riparian woodland* [Mixed riparian floodplain and gallery woodland]



Number of 10km grids	ANNEX1		
EUNIS	91E0,91F0	Other	Total
G1.2	22561	2678	25239
Other	9951	12777	22728
Total	**32512**	**15455**	**47967**
user's accuracy =		89.4%	
producer's accuracy =		69.4%	
total accuracy =		73.7%	

Map 2 Assessment of the 20 m resolution EUNIS forest habitat probability map G1.2 'Temperate and boreal hardwood riparian woodland' (above left), aggregated to a 10 km grid with % modelled presence (below left) compared with Article 17 Natura 2000 database with the same forest habitat type (91E0 and 91 F0). Followed by an error matrix (EUNIS forest habitat probability map versus Art 17 forest habitat type) based on the presence or absence of the specific habitat type with the 10km grid cells.

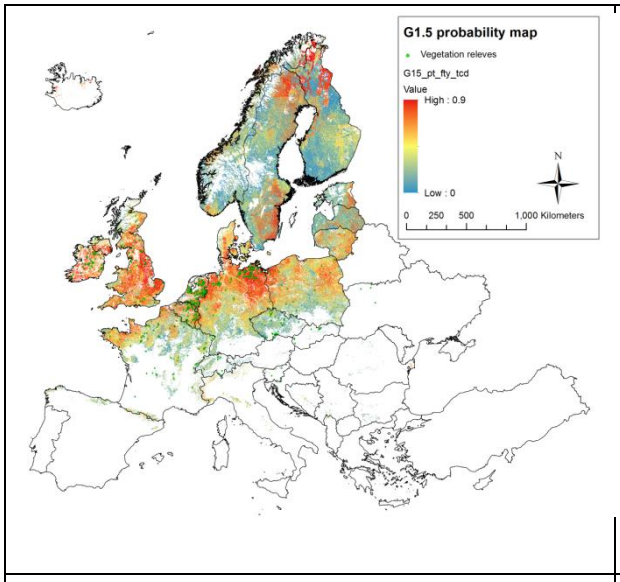
G1.3 Mediterranean and Macaronesian riparian woodland* [Mediterranean riparian woodland]

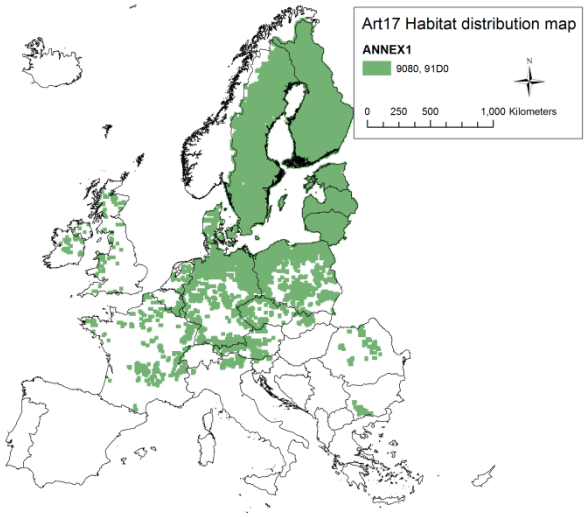


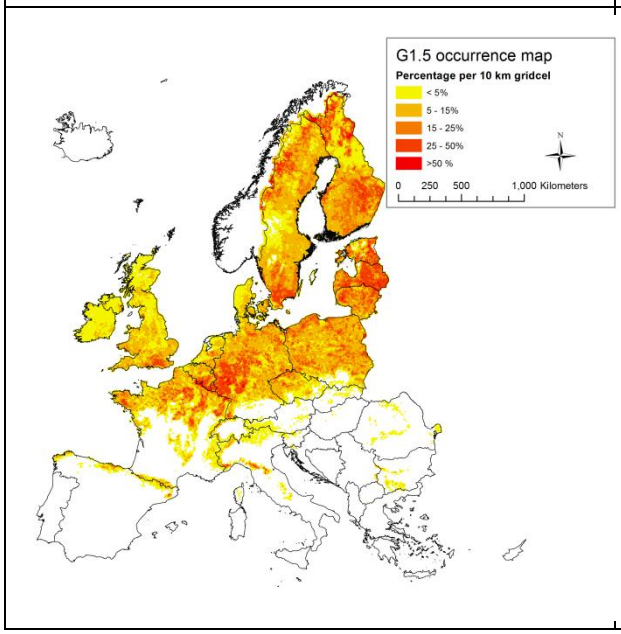
Number of 10km grids	ANNEX1		
EUNIS	92A0, 92C0	Other	total
G1.3	8050	2689	10739
Other	3257	33971	37228
total	**11307**	**36660**	**47967**
user's accuracy =		75.0%	
producer's accuracy =		71.2%	
total accuracy =		87.6%	

Map 3 Assessment of the 20 m resolution EUNIS forest habitat probability map G1.3 'Mediterranean and Macaronesian riparian woodland' (above left), aggregated to a 10 km grid with % modelled presence (below left) compared with Article 17 Natura 2000 database with the same forest habitat type (92A0 and 92C0). Followed by an error matrix (EUNIS forest habitat probability map versus Art 17 forest habitat type) based on the presence or absence of the specific habitat type with the 10km grid cells.

G1.5 Broadleaved swamp woodland on acid peat* [Broadleaved swamp woodland on acid peat]



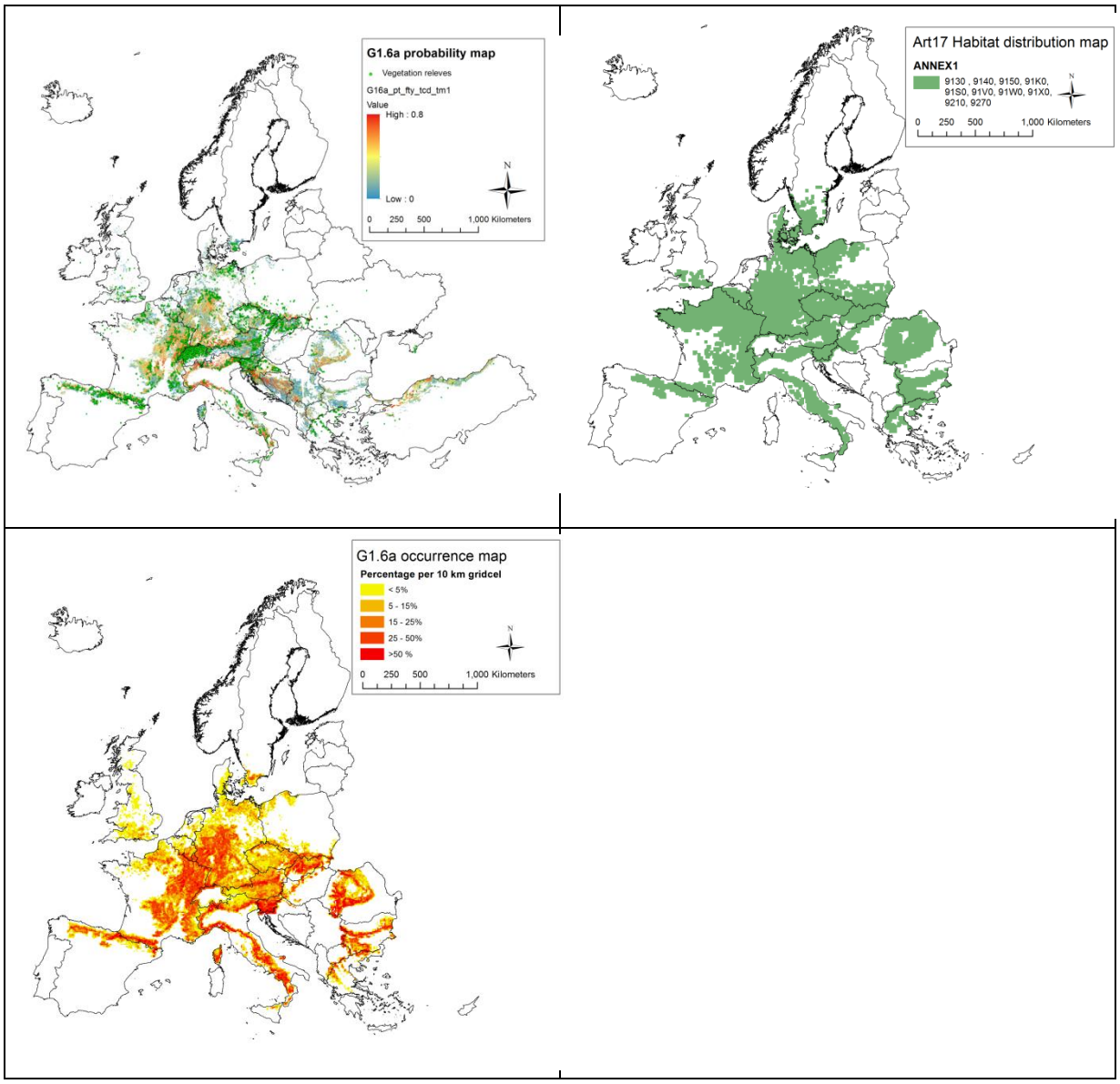




Number of 10km grids	ANNEX1		
EUNIS	9080, 91D0	Other	total
G1.5	17889	8856	26745
Other	2053	19169	21222
total	**19942**	**28025**	**47967**
user's accuracy =		66.9%	
producer's accuracy =		89.7%	
total accuracy =		77.3%	

Map 4 Assessment of the 20 m resolution EUNIS forest habitat probability map G1.5 'Broadleaved swamp woodland on acid peat' (above left), aggregated to a 10 km grid with % modelled presence (below left) compared with Article 17 Natura 2000 database with the same forest habitat type (9080 and 91D0). Followed by an error matrix (EUNIS forest habitat probability map versus Art 17 forest habitat type) based on the presence or absence of the specific habitat type with the 10km grid cells.

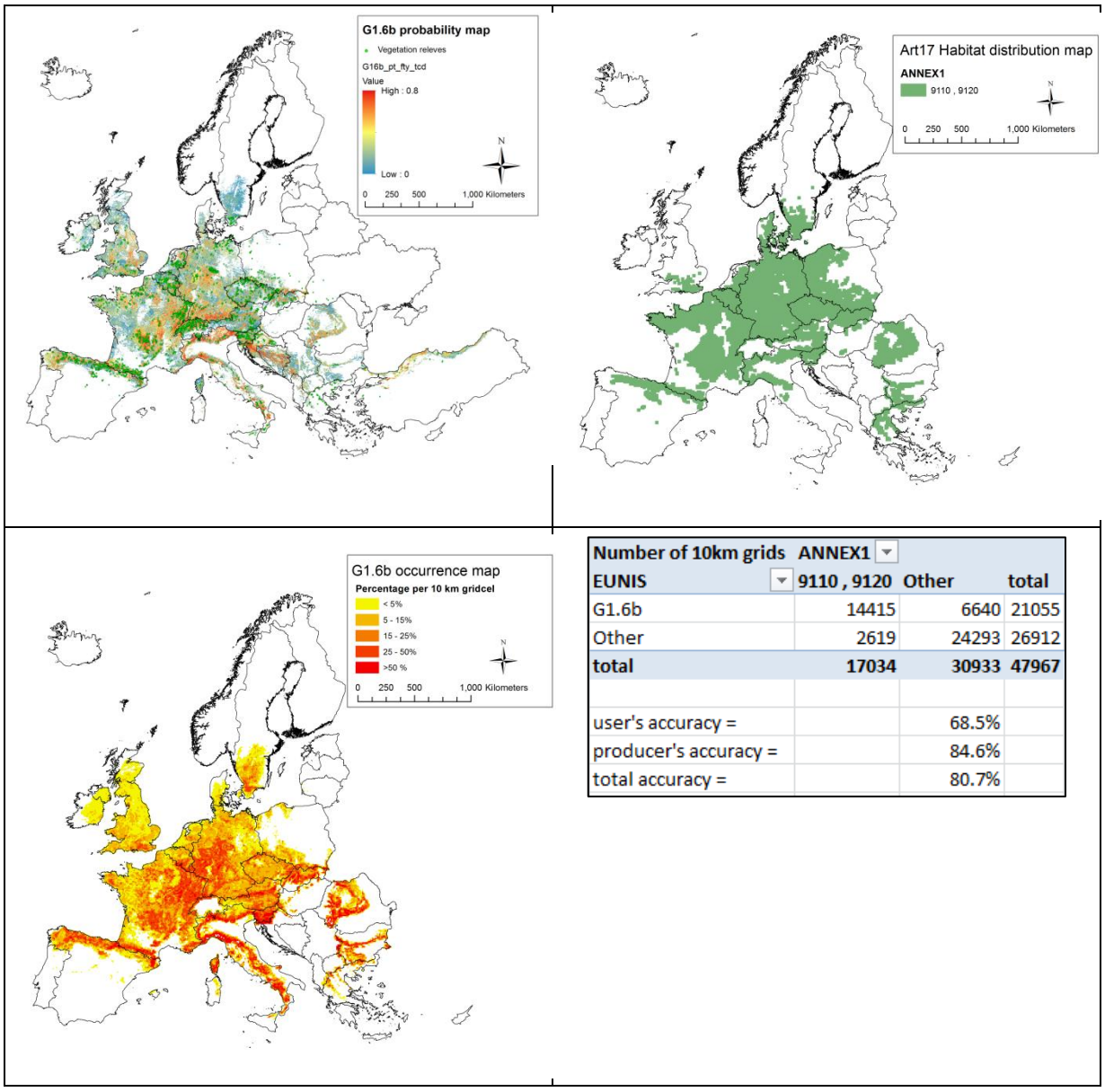
G1.6a Fagus woodland on non-acid soils



Number of 10km grids	ANNEX1		
EUNIS	9130 , 9140, 9150, 91K0, 91S0, 91V0, 91W0, 91X0, 9210, 9270	other	total
G1.6a	12597	1730	14327
Other	5882	27758	33640
total	**18479**	**29488**	**47967**
user's accuracy =		87.9%	
producer's accuracy =		68.2%	
total accuracy =		84.1%	

Map 5 Assessment of the 20 m resolution EUNIS forest habitat probability map G1.6a 'Fagus woodland on non-acid soils' (above left), aggregated to a 10 km grid with % modelled presence (below left) compared with Article 17 Natura 2000 database with the same forest habitat type (9130, 9140, 9150, 91K0, 91S0, 91V0, 91W0, 91X0, 9210,9270). Followed by an error matrix (EUNIS forest habitat probability map versus Art 17 forest habitat type) based on the presence or absence of the specific habitat type with the 10km grid cells.

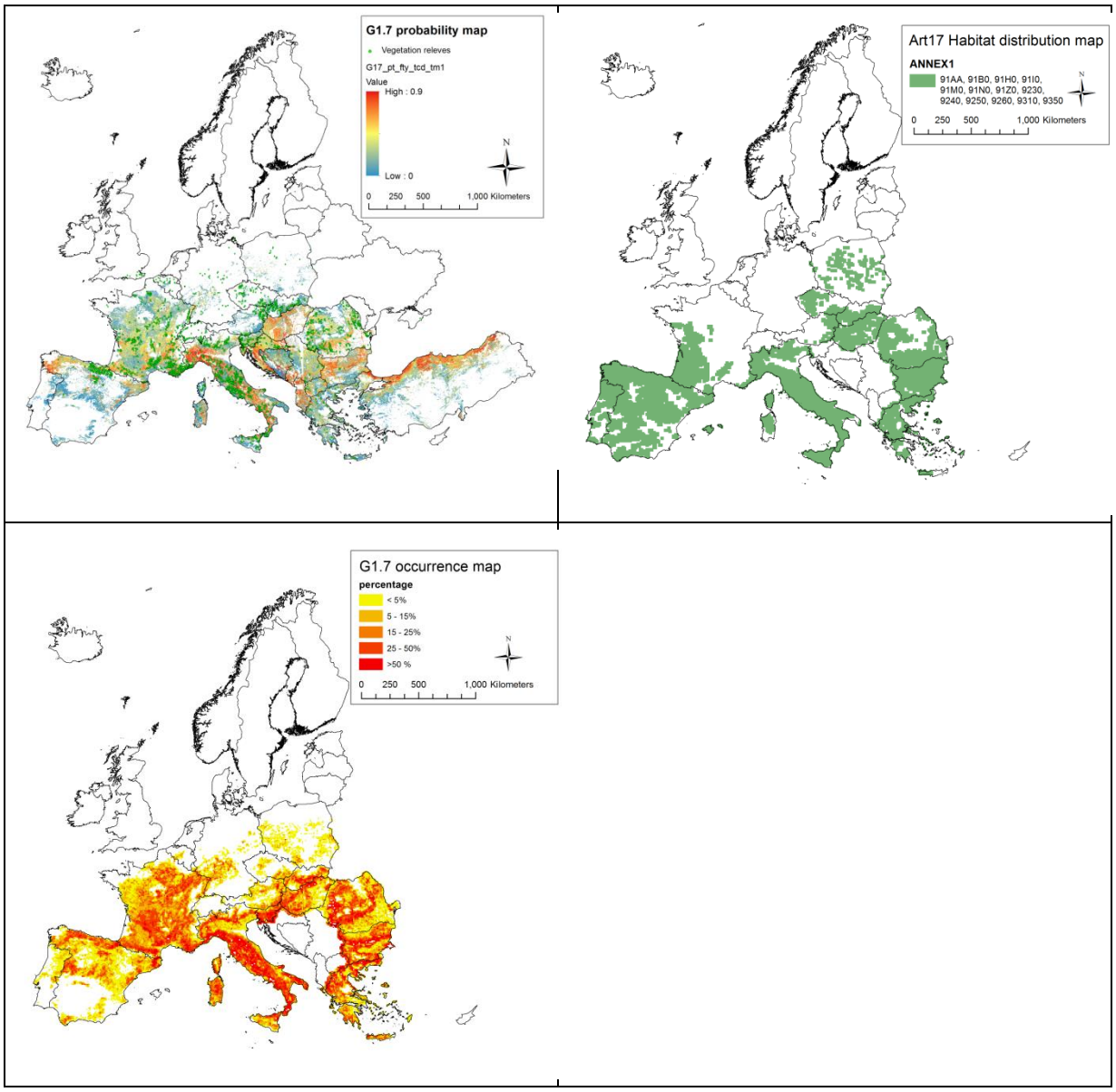
G1.6b Fagus woodland on acid soils



Number of 10km grids	ANNEX1		
EUNIS	9110 , 9120	Other	total
G1.6b	14415	6640	21055
Other	2619	24293	26912
total	**17034**	**30933**	**47967**
user's accuracy =		68.5%	
producer's accuracy =		84.6%	
total accuracy =		80.7%	

Map 6 Assessment of the 20 m resolution EUNIS forest habitat probability map G1.6b 'Fagus woodland on acid soils' (above left), aggregated to a 10 km grid with % modelled presence (below left) compared with Article 17 Natura 2000 database with the same forest habitat type (9110 and 9120). Followed by an error matrix (EUNIS forest habitat probability map versus Art 17 forest habitat type) based on the presence or absence of the specific habitat type with the 10km grid cells.

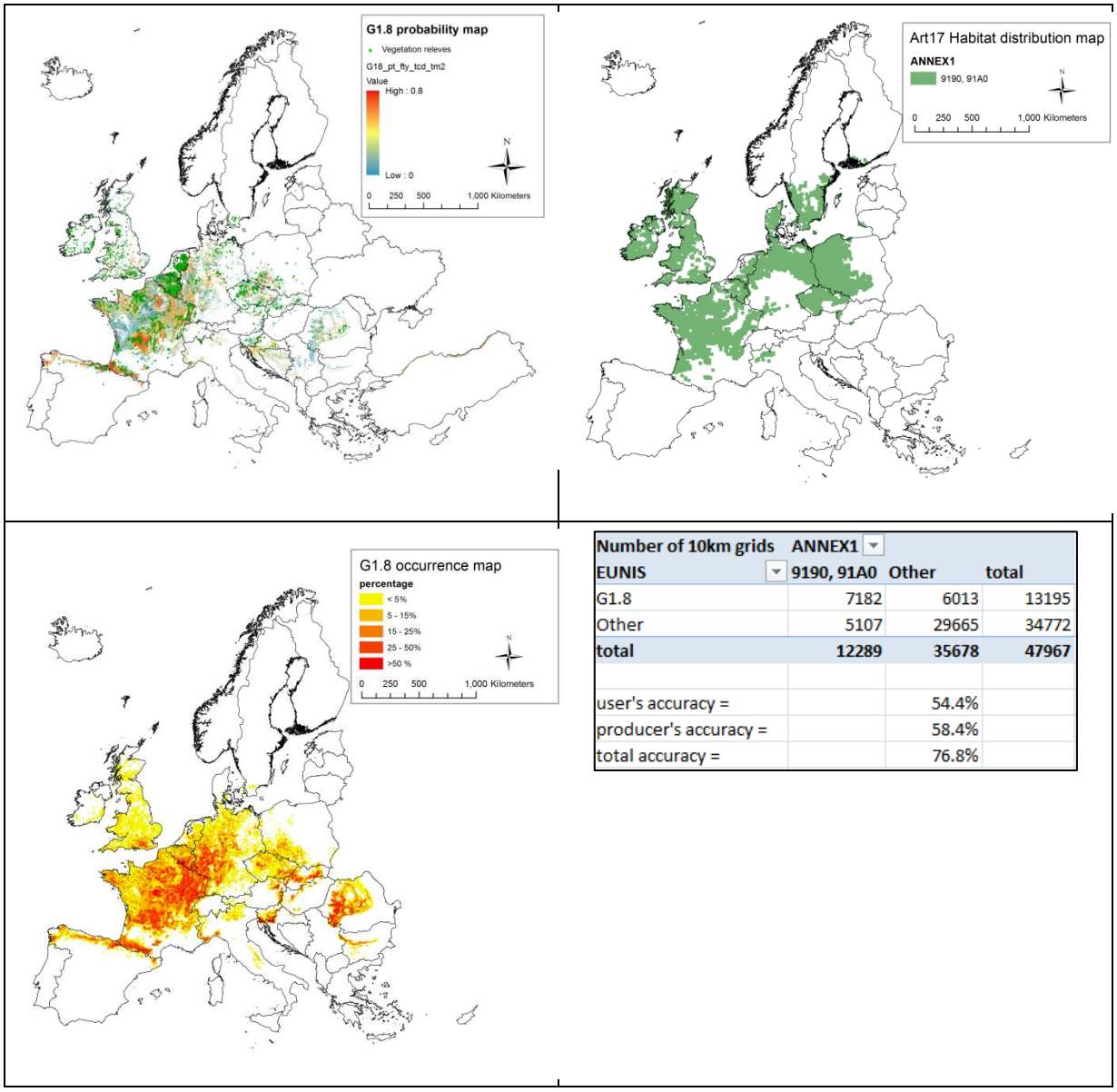
G1.7 Thermophilous deciduous woodland



Number of 10km grids	ANNEX1		
EUNIS	91AA, 91B0, 91H0, 91I0, 91M0, 91N0, 91Z0, 9230, 9240, 9250, 9260, 9310, 9350	Other	total
G1.7	13040	6792	19832
Other	3533	24602	28135
total	**16573**	**31394**	**47967**
user's accuracy =		65.8%	
producer's accuracy =		78.7%	
total accuracy =		78.5%	

Map 7 Assessment of the 20 m resolution EUNIS forest habitat probability map G1.7 'Thermophilous deciduous woodland' (above left), aggregated to a 10 km grid with % modelled presence (below left) compared with Article 17 Natura 2000 database with the same forest habitat type (91AA, 01B0, 91H0, 91M0, 91N0, 91Z0, 9230, 9240, 9250,9260, 9310, 9350). Followed by an error matrix (EUNIS forest habitat probability map versus Art 17 forest habitat type) based on the presence or absence of the specific habitat type with the 10km grid cells.

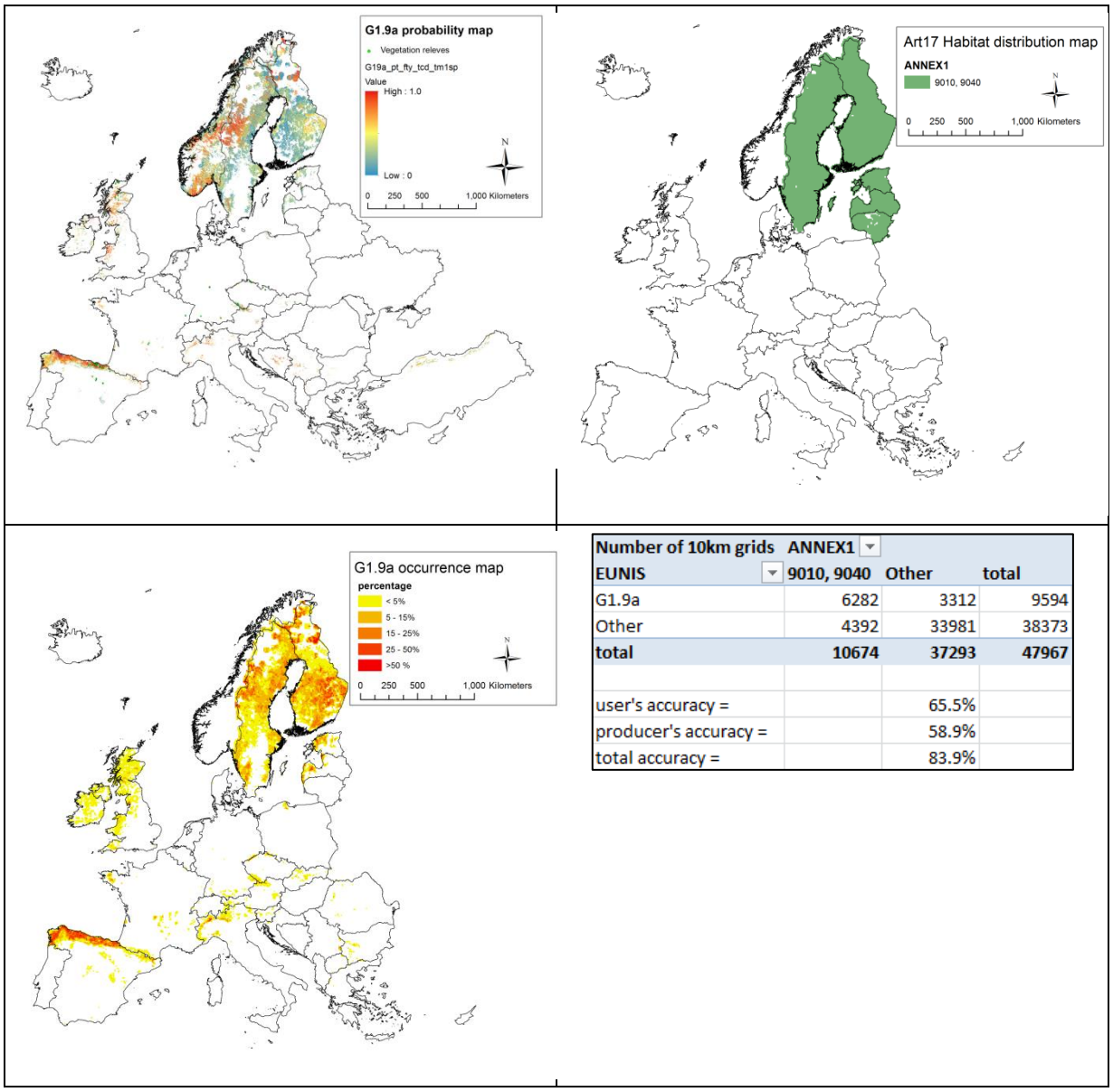
G1.8 Acidophilous Quercus woodland* [Acidophilous [Quercus]-dominated woodland]



Number of 10km grids	ANNEX1		
EUNIS	9190, 91A0	Other	total
G1.8	7182	6013	13195
Other	5107	29665	34772
total	**12289**	**35678**	**47967**
user's accuracy =		54.4%	
producer's accuracy =		58.4%	
total accuracy =		76.8%	

Map 8 Assessment of the 20 m resolution EUNIS forest habitat probability map G1.8 'Acidophilous Quercus woodland' (above left), aggregated to a 10 km grid with % modelled presence (below left) compared with Article 17 Natura 2000 database with the same forest habitat type (9190,91A0). Followed by an error matrix (EUNIS forest habitat probability map versus Art 17 forest habitat type) based on the presence or absence of the specific habitat type with the 10km grid cells.

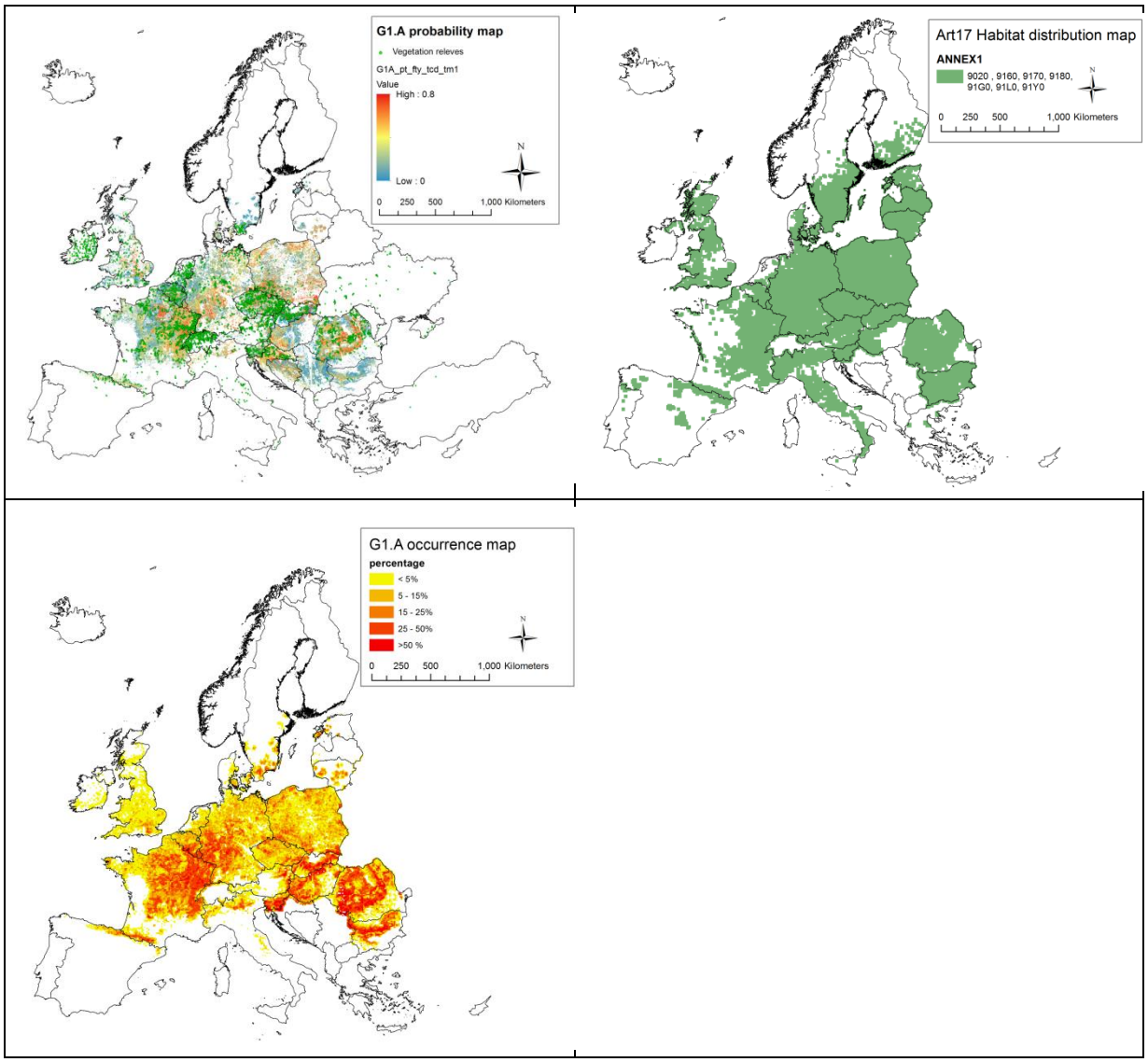
G1.9a Mountain Betula and Populus tremula woodlands on mineral soils



Number of 10km grids	ANNEX1		
EUNIS	9010, 9040	Other	total
G1.9a	6282	3312	9594
Other	4392	33981	38373
total	**10674**	**37293**	**47967**
user's accuracy =		65.5%	
producer's accuracy =		58.9%	
total accuracy =		83.9%	

Map 9 Assessment of the 20 m resolution EUNIS forest habitat probability map G1.9a 'Mountain Betula and Populus tremula woodlands on mineral soils' (above left), aggregated to a 10 km grid with % modelled presence (below left) compared with Article 17 Natura 2000 database with the same forest habitat type (9010, 9040). Followed by an error matrix (EUNIS forest habitat probability map versus Art 17 forest habitat type) based on the presence or absence of the specific habitat type with the 10km grid cells.

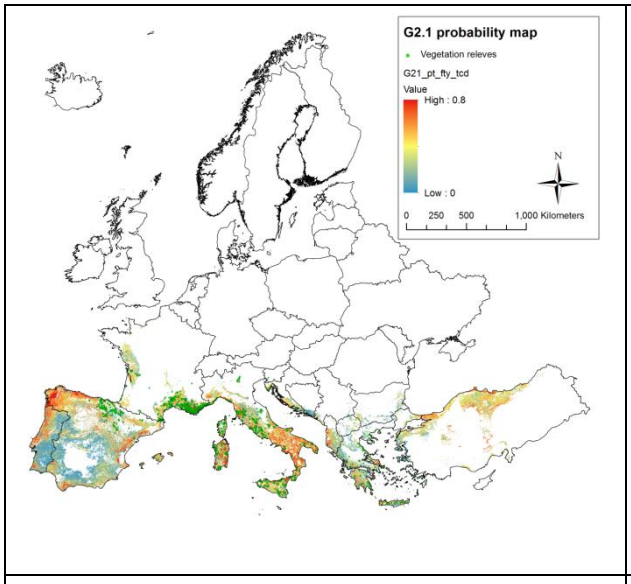
G1.A Mesotrophic and eutrophic deciduous woodland, not dominated by Fagus* [Meso- and eutrophic [Quercus], [Carpinus], [Fraxinus], [Acer], [Tilia], [Ulmus] and related woodland]

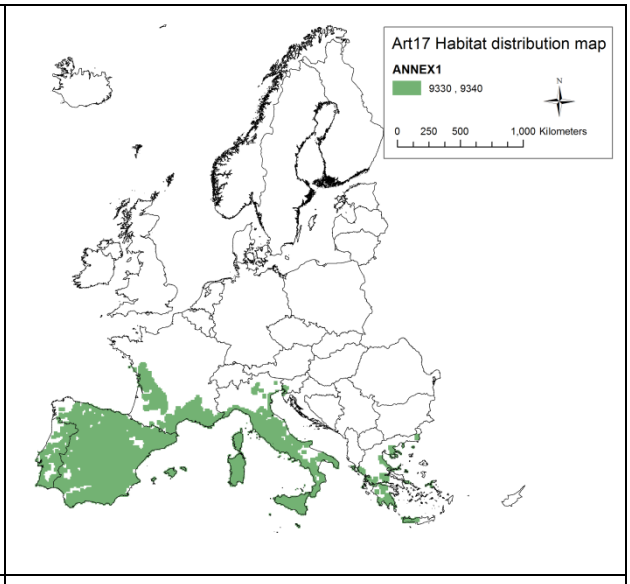


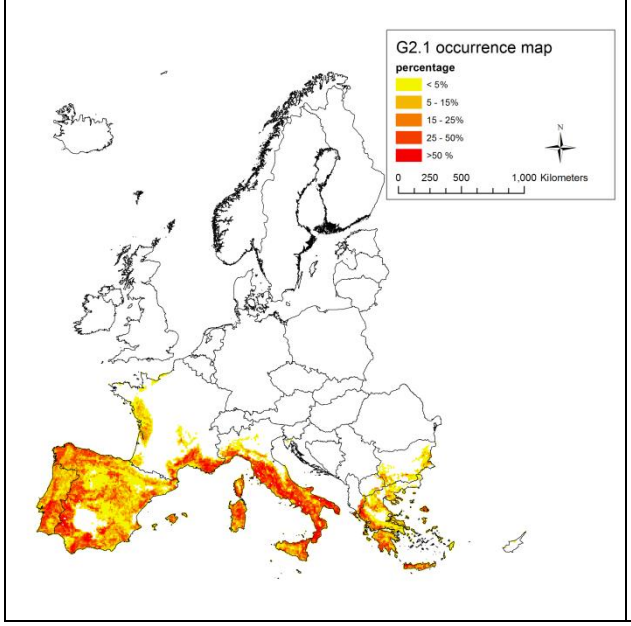
Number of 10km grids	ANNEX1		
EUNIS	9020 , 9160, 9170, 9180, 91G0, 91L0, 91Y0	Other	total
G1.A	17302	2552	19854
Other	9457	18656	28113
total	**26759**	**21208**	**47967**
user's accuracy =		87.1%	
producer's accuracy =		64.7%	
total accuracy =		75.0%	

Map 10 Assessment of the 20 m resolution EUNIS forest habitat probability map G1.A 'Mesotrophic and eutrophic deciduous woodland, not dominated by Fagus' (above left), aggregated to a 10 km grid with % modelled presence (below left) compared with Article 17 Natura 2000 database with the same forest habitat type (9010, 9040). Followed by an error matrix (EUNIS forest habitat probability map versus Art 17 forest habitat type) based on the presence or absence of the specific habitat type with the 10km grid cells.

G2.1 Mediterranean evergreen Quercus woodland* [Mediterranean evergreen [Quercus] woodland]



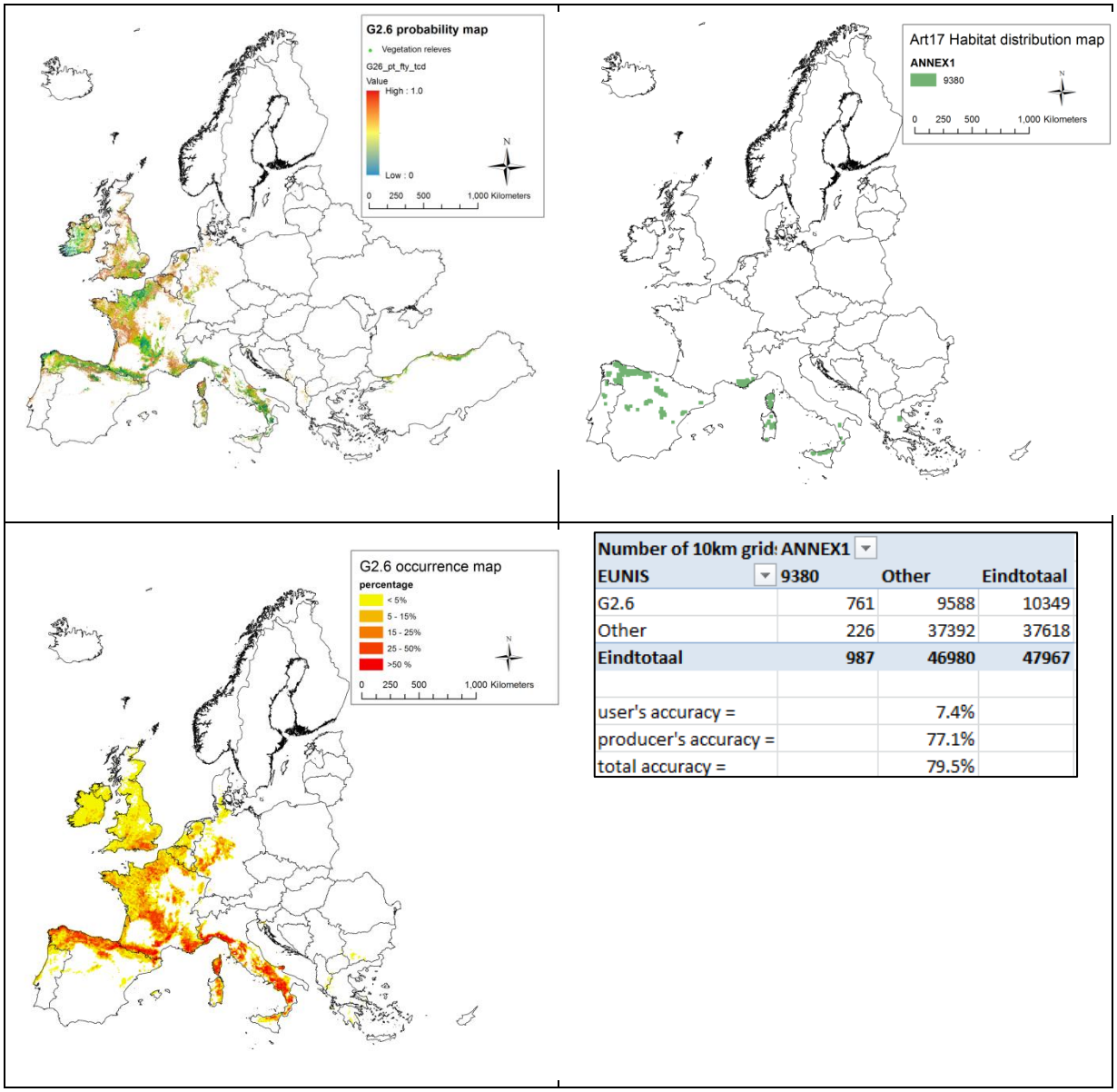




Number of 10km grids	ANNEX1		
EUNIS	9330 , 9340	Other	total
G2.1	8231	2627	10858
Other	1605	35504	37109
total	**9836**	**38131**	**47967**
user's accuracy =		75.8%	
producer's accuracy =		83.7%	
total accuracy =		91.2%	

Map 11 Assessment of the 20 m resolution EUNIS forest habitat probability map G2.1 'Mediterranean evergreen Quercus woodland' (above left), aggregated to a 10 km grid with % modelled presence (below left) compared with Article 17 Natura 2000 database with the same forest habitat type (9330, 9340). Followed by an error matrix (EUNIS forest habitat probability map versus Art 17 forest habitat type) based on the presence or absence of the specific habitat type with the 10km grid cells.

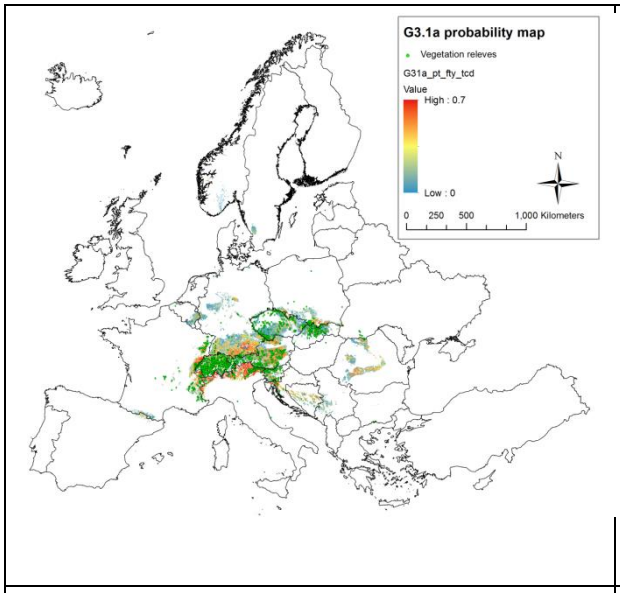
G2.6 Ilex aquifolium woodland* [[Ilex aquifolium] woods]

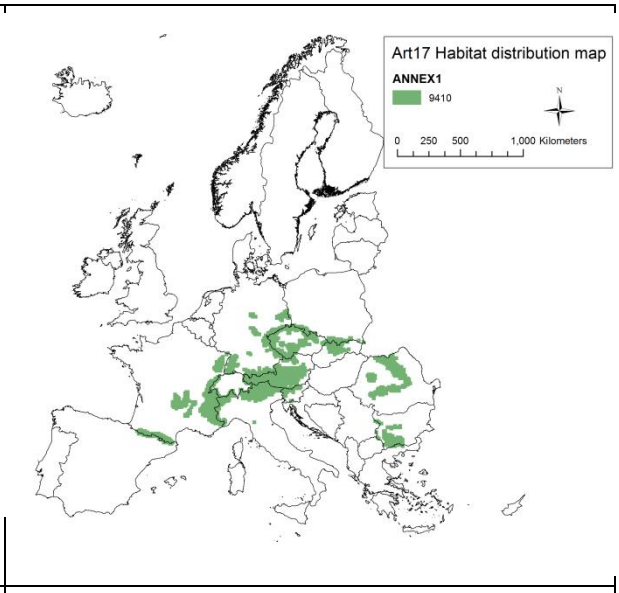


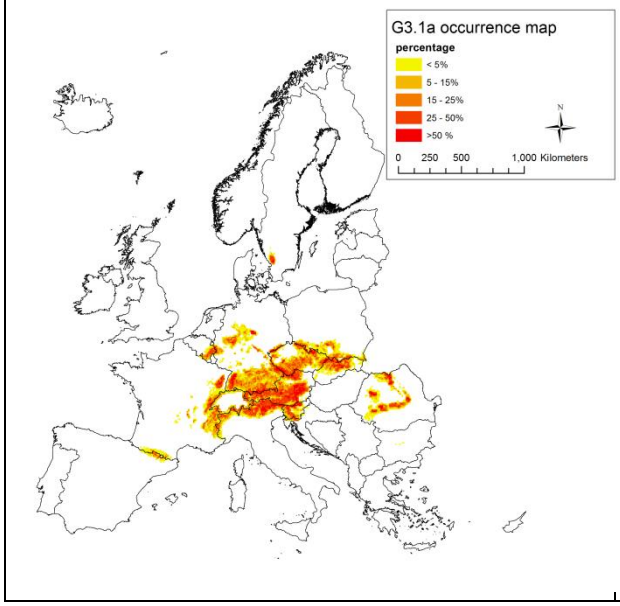
Number of 10km grid	ANNEX1		
EUNIS	9380	Other	Eindtotaal
G2.6	761	9588	10349
Other	226	37392	37618
Eindtotaal	**987**	**46980**	**47967**
user's accuracy =		7.4%	
producer's accuracy =		77.1%	
total accuracy =		79.5%	

Map 12 Assessment of the 20 m resolution EUNIS forest habitat probability map G2.6 'Ilex aquifolium woodland' (above left), aggregated to a 10 km grid with % modelled presence (below left) compared with Article 17 Natura 2000 database with the same forest habitat type (9380). Followed by an error matrix (EUNIS forest habitat probability map versus Art 17 forest habitat type) based on the presence or absence of the specific habitat type with the 10km grid cells.

G3.1a Temperate mountain Picea woodland



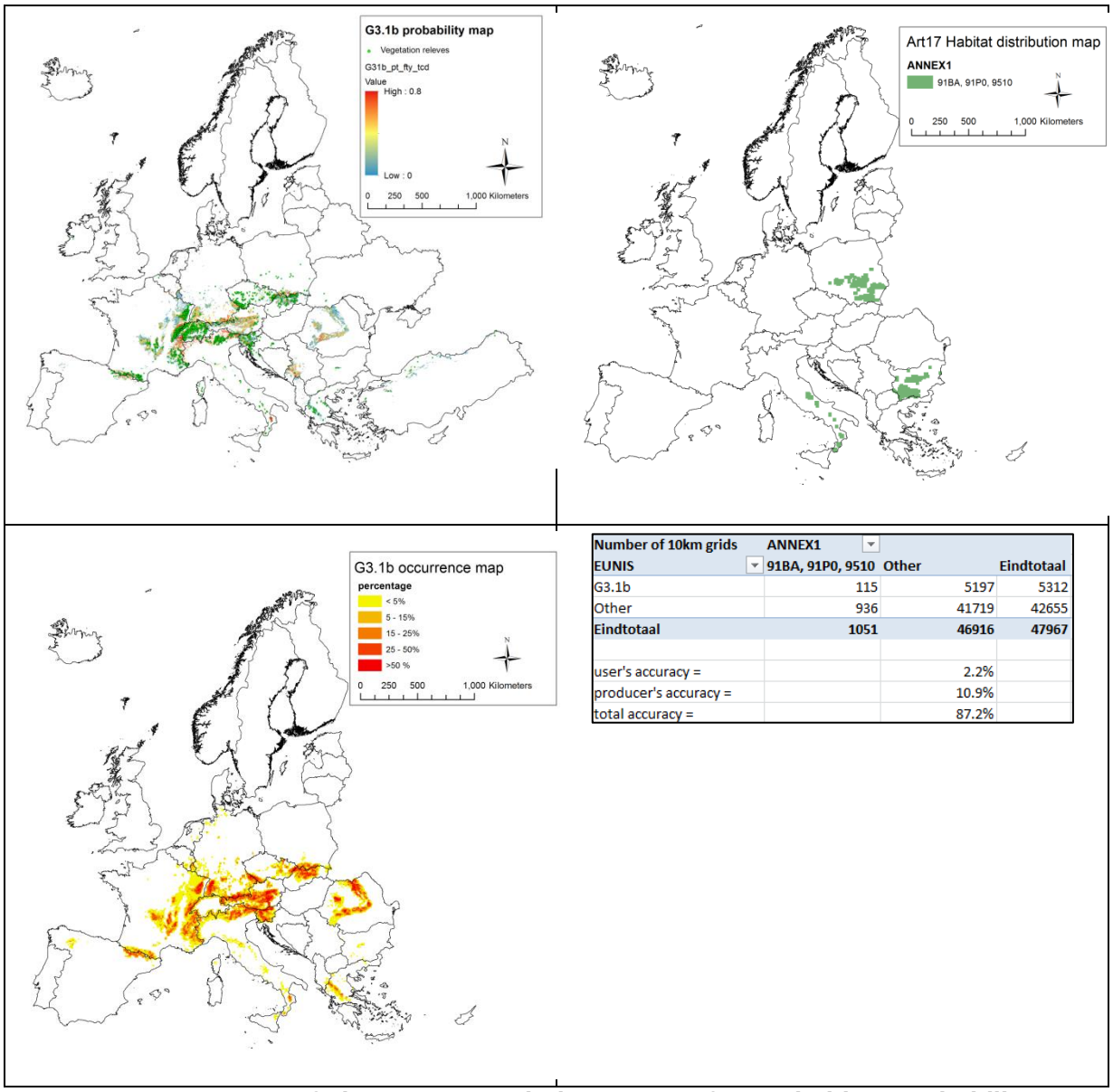




Number of 10km grids	ANNEX1		
EUNIS	9410	Other	total
G3.1a	3364	1903	5267
Other	1193	41507	42700
total	**4557**	**43410**	**47967**
user's accuracy =		63.9%	
producer's accuracy =		73.8%	
total accuracy =		93.5%	

Map 13 Assessment of the 20 m resolution EUNIS forest habitat probability map G3.1A 'Temperate mountain Picea woodland' (above left), aggregated to a 10 km grid with % modelled presence (below left) compared with Article 17 Natura 2000 database with the same forest habitat type (9410). Followed by an error matrix (EUNIS forest habitat probability map versus Art 17 forest habitat type) based on the presence or absence of the specific habitat type with the 10km grid cells.

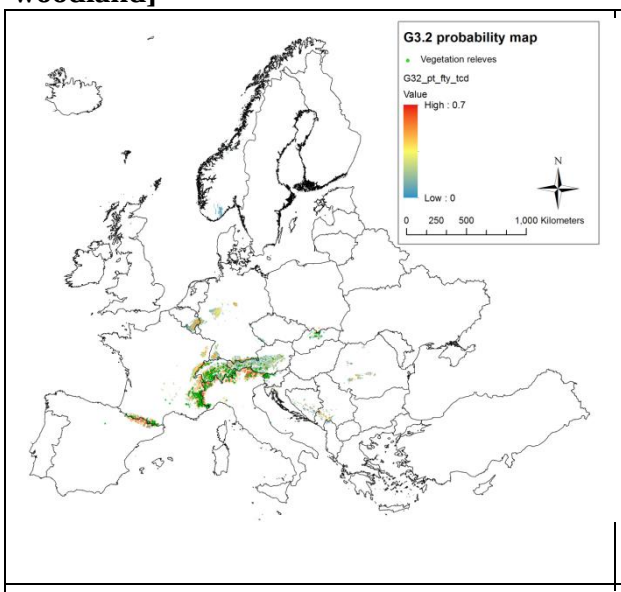
G3.1b Temperate mountain Abies woodland

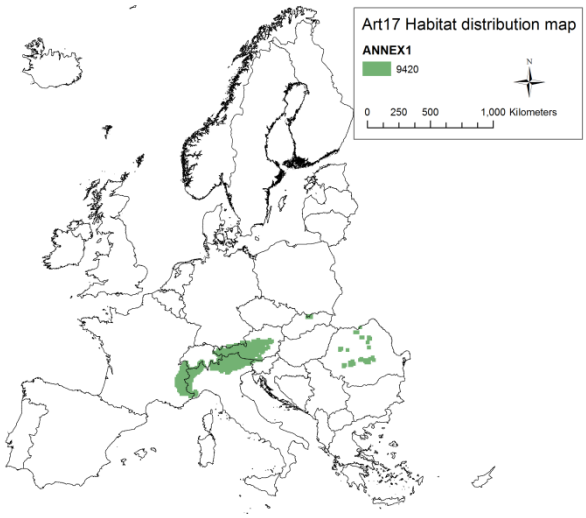


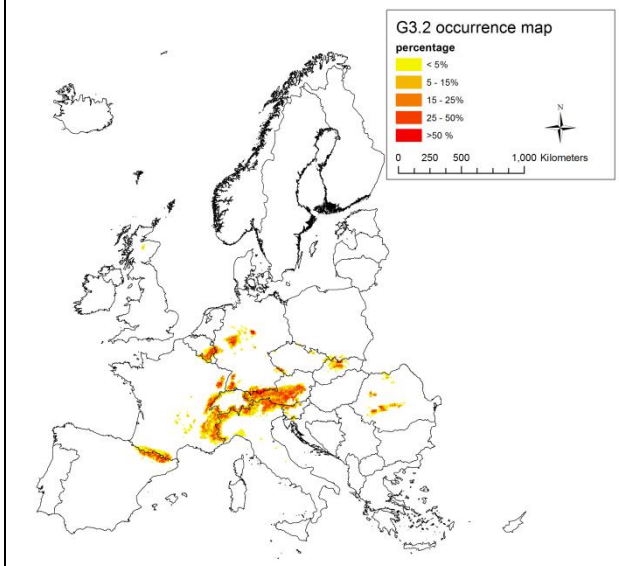
Number of 10km grids	ANNEX1		
EUNIS	91BA, 91P0, 9510	Other	Eindtotaal
G3.1b	115	5197	5312
Other	936	41719	42655
Eindtotaal	**1051**	**46916**	**47967**
user's accuracy =		2.2%	
producer's accuracy =		10.9%	
total accuracy =		87.2%	

Map 14 Assessment of the 20 m resolution EUNIS forest habitat probability map G3.1B 'Temperate mountain Abies woodland' (above left), aggregated to a 10 km grid with % modelled presence (below left) compared with Article 17 Natura 2000 database with the same forest habitat type (91BA, 91P0, 9510). Followed by an error matrix (EUNIS forest habitat probability map versus Art 17 forest habitat type) based on the presence or absence of the specific habitat type with the 10km grid cells.

G3.2 Temperate subalpine Larix-Pinus woodland* [Alpine [Larix] - [Pinus cembra] woodland]



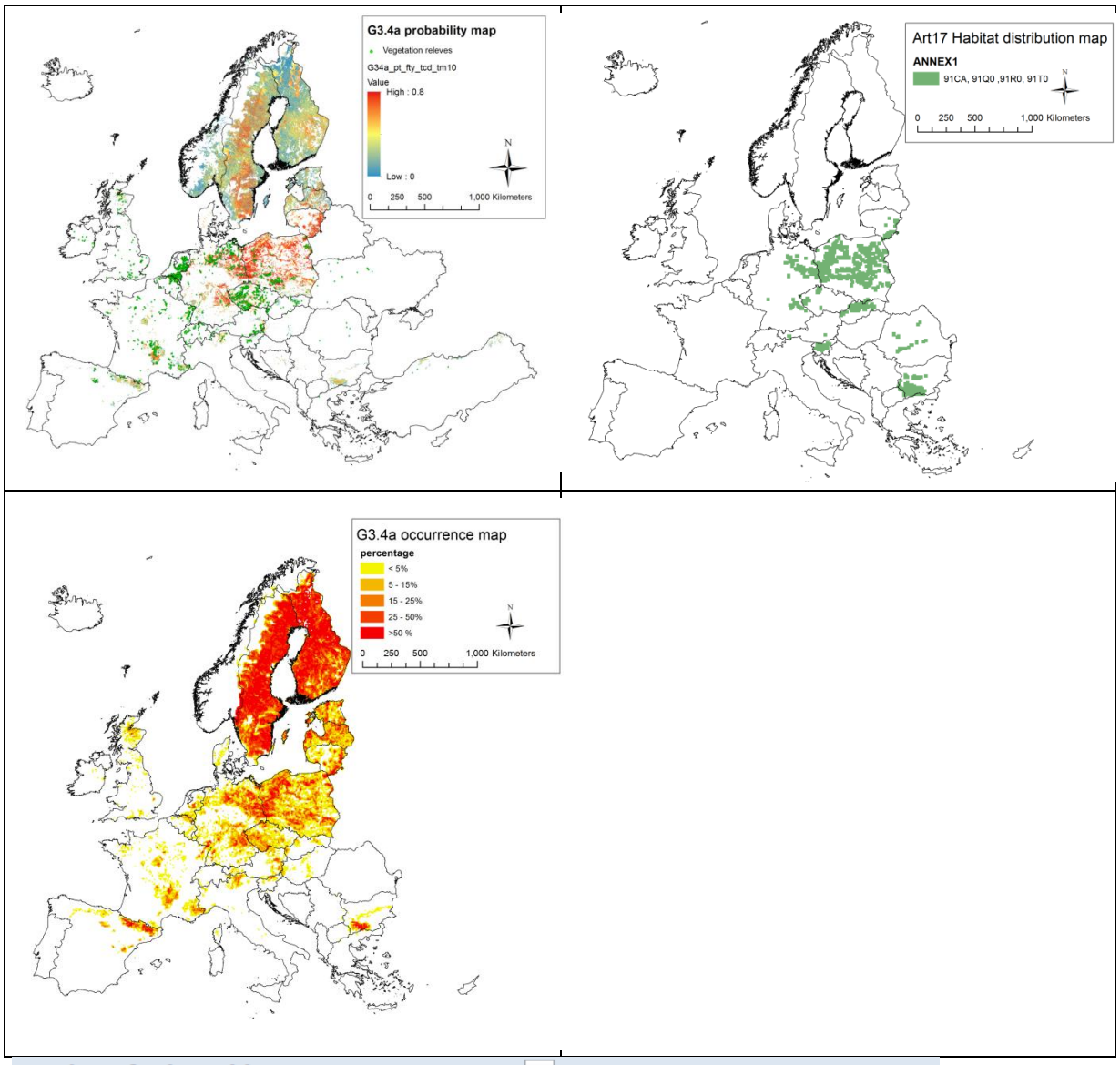




Number of 10km grids	ANNEX1		
EUNIS	9420	Other	Eindtotaal
G3.2	1270	1325	2595
Other	273	45099	45372
Eindtotaal	**1543**	**46424**	**47967**
user's accuracy =		48.9%	
producer's accuracy =		82.3%	
total accuracy =		96.7%	

Map 15 Assessment of the 20 m resolution EUNIS forest habitat probability map G3.2 'Temperate subalpine Larix-Pinus woodland' (above left), aggregated to a 10 km grid with % modelled presence (below left) compared with Article 17 Natura 2000 database with the same forest habitat type (9420). Followed by an error matrix (EUNIS forest habitat probability map versus Art 17 forest habitat type) based on the presence or absence of the specific habitat type with the 10km grid cells.

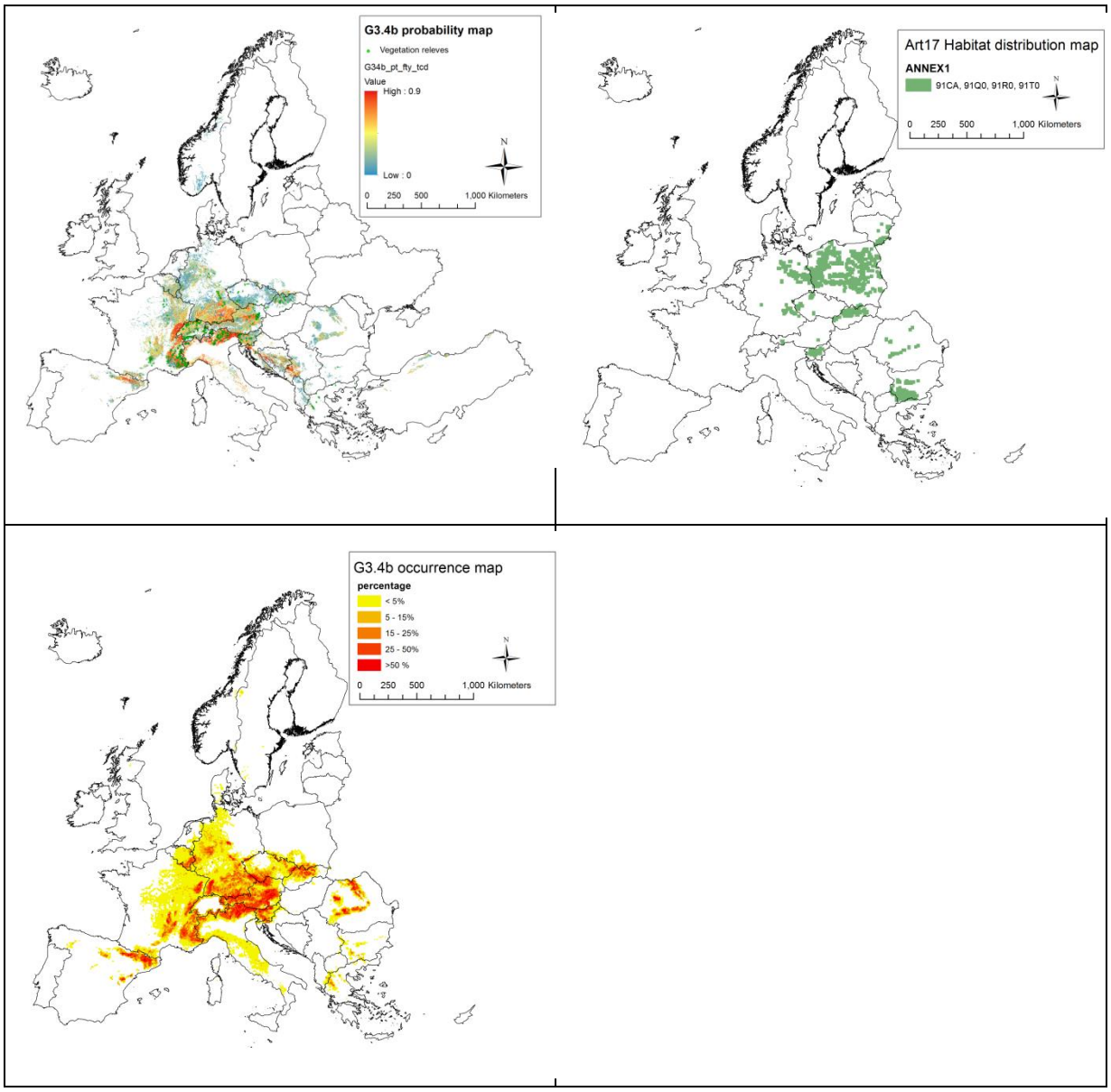
G3.4a Temperate continental Pinus sylvestris woodland



Number of 10km grids	ANNEX1		
EUNIS	91CA,91Q0,91R0,91T0	Other	Eindtotaal
G3.4a	2414	14908	17322
Other	653	29992	30645
Eindtotaal	**3067**	**44900**	**47967**
user's accuracy =		13.9%	
producer's accuracy =		78.7%	
total accuracy =		67.6%	

Map 16 Assessment of the 20 m resolution EUNIS forest habitat probability map G3.4a 'Temperate continental Pinus sylvestris woodland' (above left), aggregated to a 10 km grid with % modelled presence (below left) compared with Article 17 Natura 2000 database with the same forest habitat type (91CA, 91Q0, 91R0, 91T0). Followed by an error matrix (EUNIS forest habitat probability map versus Art 17 forest habitat type) based on the presence or absence of the specific habitat type with the 10km grid cells.

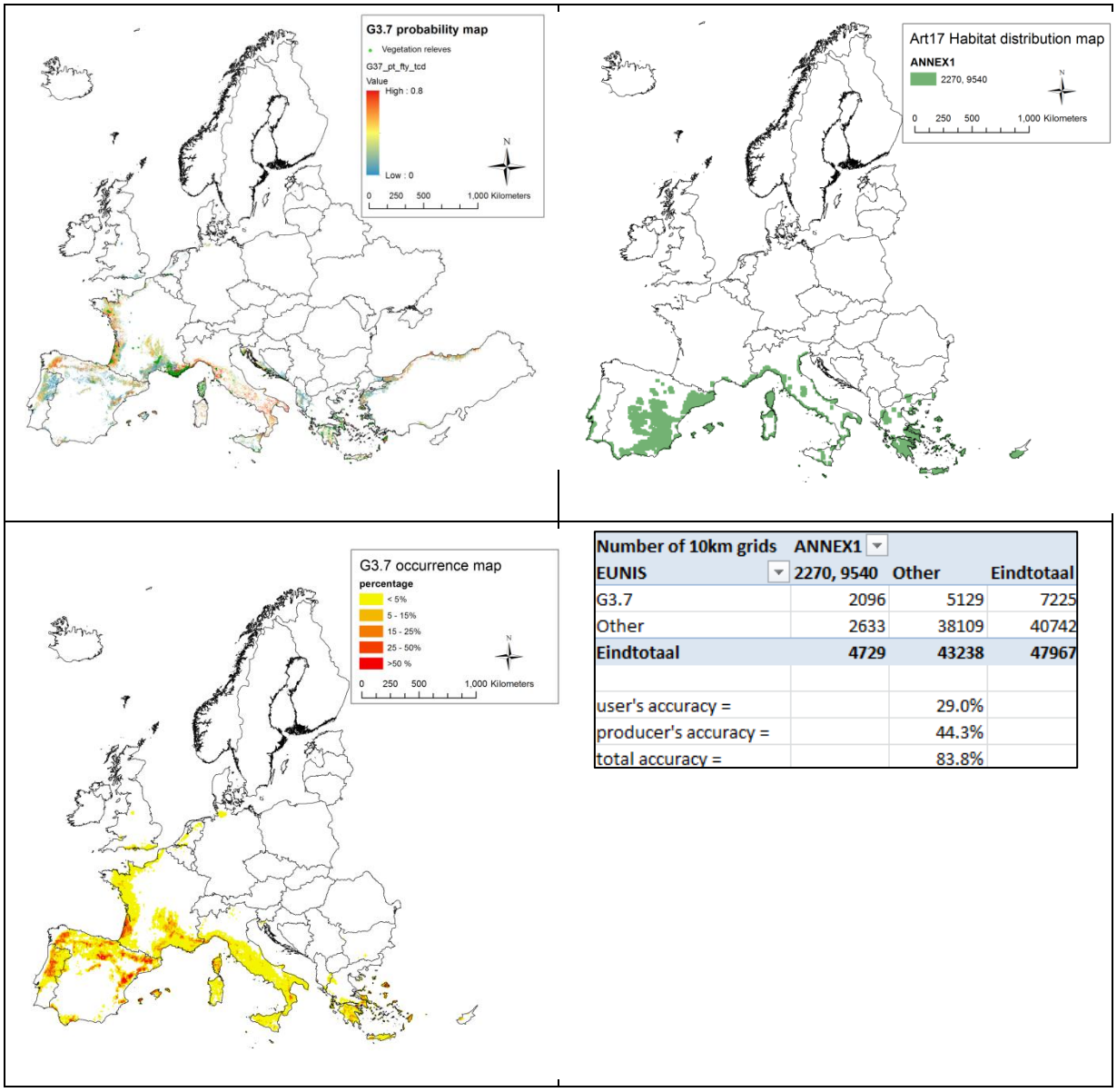
G3.4b Temperate and submediterranean montane Pinus sylvestris-nigra woodland



Number of 10km grids	ANNEX1		
EUNIS	91CA,91Q0,91R0,91T0	Other	Eindtotaal
G3.4b	723	9454	10177
Other	2344	35446	37790
Eindtotaal	**3067**	**44900**	**47967**
user's accuracy =		7.1%	
producer's accuracy =		23.6%	
total accuracy =		75.4%	

Map 17 Assessment of the 20 m resolution EUNIS forest habitat probability map G3.4b 'Temperate and submediterranean montane Pinus sylvestris-nigra woodland' (above left), aggregated to a 10 km grid with % modelled presence (below left) compared with Article 17 Natura 2000 database with the same forest habitat type (91CA, 91Q0, 91R0, 91T0). Followed by an error matrix (EUNIS forest habitat probability map versus Art 17 forest habitat type) based on the presence or absence of the specific habitat type with the 10km grid cells.

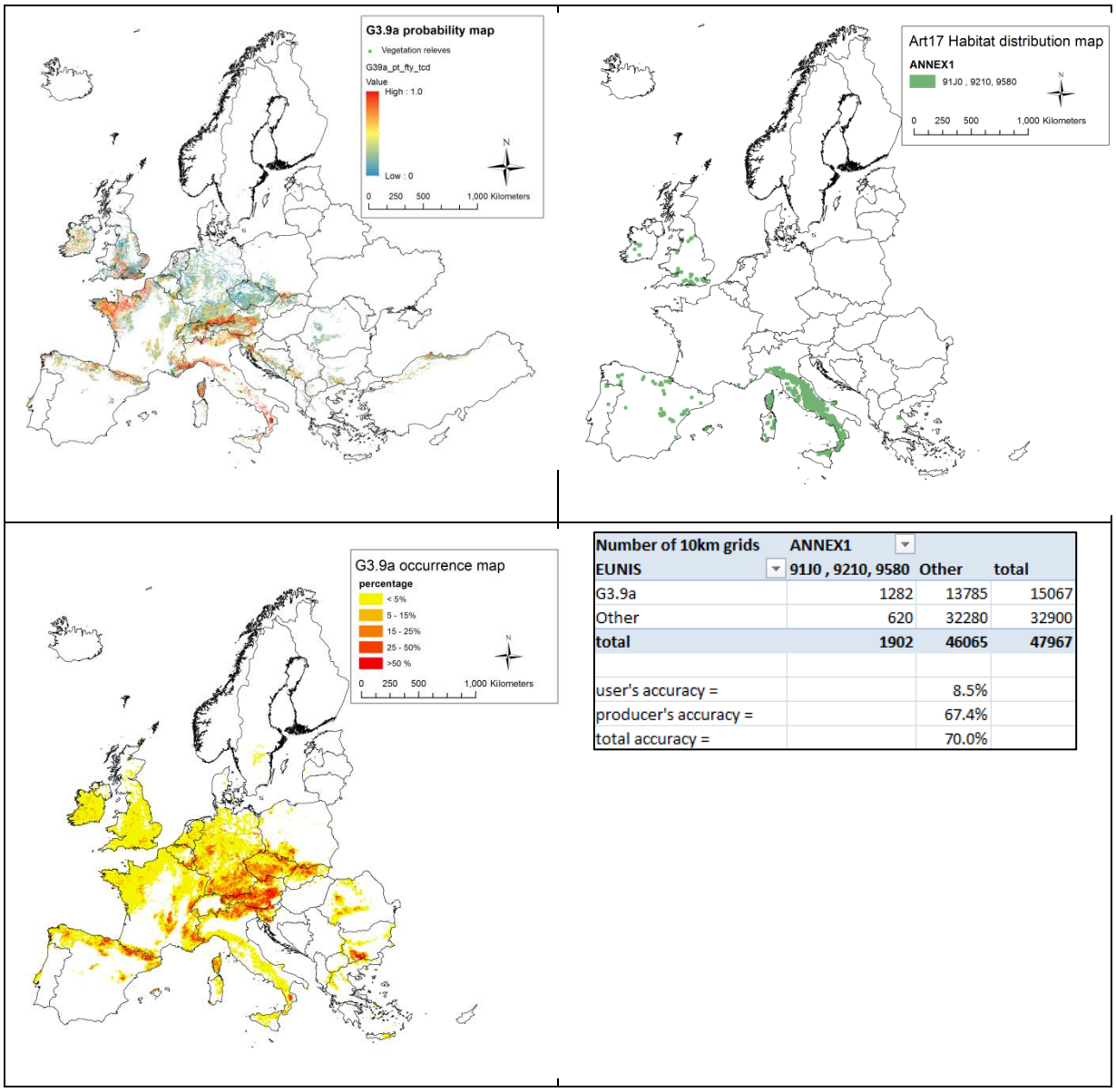
G3.7 Mediterranean lowland to submontane Pinus woodland* [Lowland to montane mediterranean [Pinus] woodland (excluding [Pinus nigra])]



Number of 10km grids	ANNEX1		
EUNIS	2270, 9540	Other	Eindtotaal
G3.7	2096	5129	7225
Other	2633	38109	40742
Eindtotaal	**4729**	**43238**	**47967**
user's accuracy =		29.0%	
producer's accuracy =		44.3%	
total accuracy =		83.8%	

Map 18 Assessment of the 20 m resolution EUNIS forest habitat probability map G3.7 'Mediterranean lowland to submontane Pinus woodland' (above left), aggregated to a 10 km grid with % modelled presence (below left) compared with Article 17 Natura 2000 database with the same forest habitat type (2270, 9540). Followed by an error matrix (EUNIS forest habitat probability map versus Art 17 forest habitat type) based on the presence or absence of the specific habitat type with the 10km grid cells.

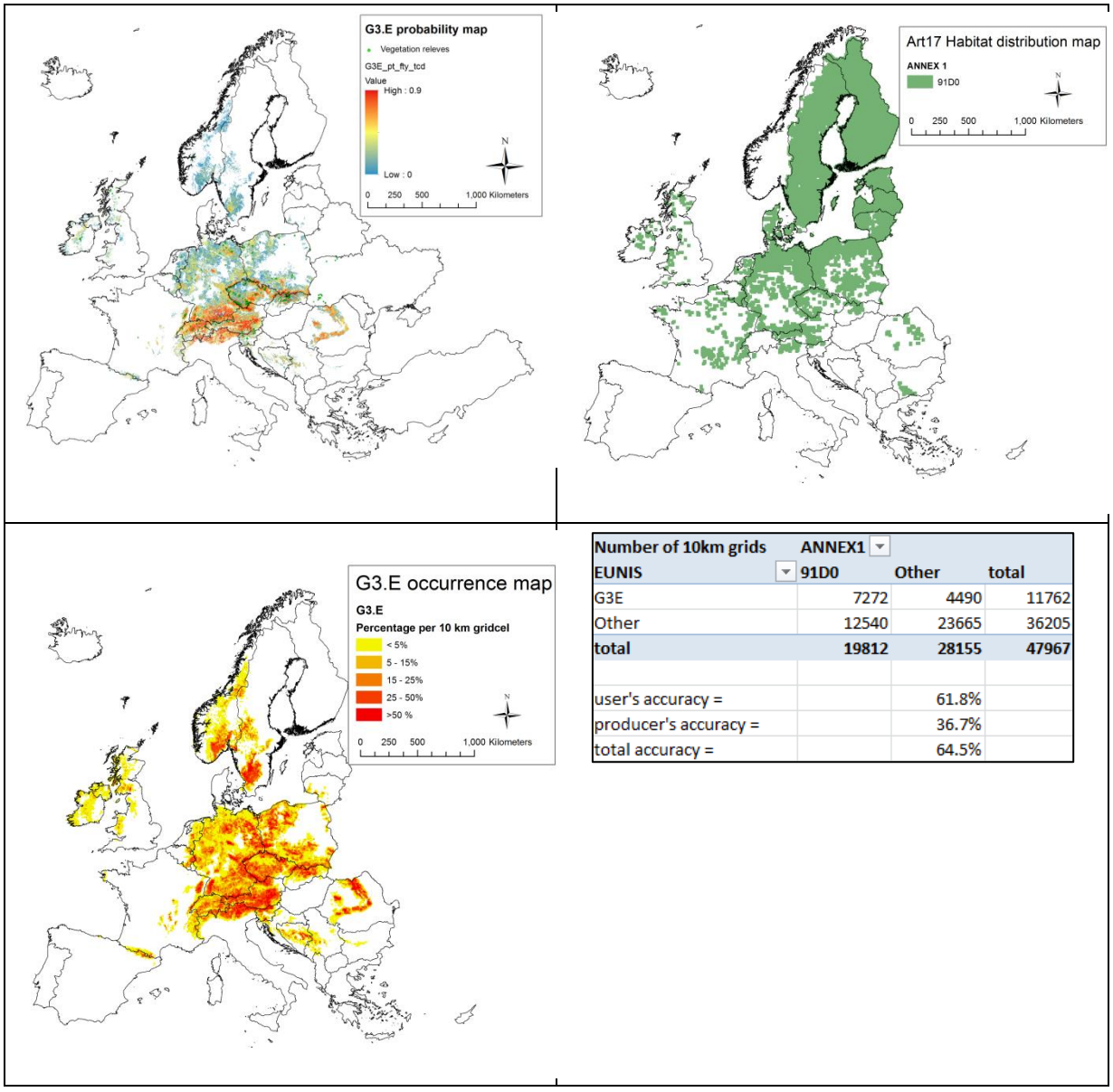
G3.9a Taxus baccata woodland



Number of 10km grids	ANNEX1		
EUNIS	91J0 , 9210, 9580	Other	total
G3.9a	1282	13785	15067
Other	620	32280	32900
total	**1902**	**46065**	**47967**
user's accuracy =		8.5%	
producer's accuracy =		67.4%	
total accuracy =		70.0%	

Map 19 Assessment of the 20 m resolution EUNIS forest habitat probability map G3.9a 'Taxus baccata woodland' (above left), aggregated to a 10 km grid with % modelled presence (below left) compared with Article 17 Natura 2000 database with the same forest habitat type (91J0, 9210, 9580). Followed by an error matrix (EUNIS forest habitat probability map versus Art 17 forest habitat type) based on the presence or absence of the specific habitat type with the 10km grid cells.

G3.E Temperate bog conifer woodland* [Nemoral bog conifer woodland]



Number of 10km grids	ANNEX1		
EUNIS	91D0	Other	total
G3E	7272	4490	11762
Other	12540	23665	36205
total	**19812**	**28155**	**47967**
user's accuracy =		61.8%	
producer's accuracy =		36.7%	
total accuracy =		64.5%	

Map 20 Assessment of the 20 m resolution EUNIS forest habitat probability map G3.E 'Temperate bog conifer woodland' (above left), aggregated to a 10 km grid with % modelled presence (below left) compared with Article 17 Natura 2000 database with the same forest habitat type (91D0). Followed by an error matrix (EUNIS forest habitat probability map versus Art 17 forest habitat type) based on the presence or absence of the specific habitat type with the 10km grid cells.

3 Conclusions and outlook

The comparison of the two independent but related data sources is quite interesting (our modelled EUNIS forest habitat probability maps versus the related Natura 2000 habitat types from the Article 17 database), but should be treated with some care since there is no one-to-one relationship between EUNIS and Natura 2000 habitat types (see Table 3). On the hand we have the vegetation plots from the European Vegetation Archive (EVA) that have been used for environmental niche modelling and the resulting EUNIS habitat suitability maps that have been intersected with the actual Copernicus HR layers to obtain EUNIS forest habitat probability maps. On the other hand we have the national Natura 2000 habitat information that have been collected for the Article 17 database of the Habitat Directive. The Article 17 database has been used as a reference for the assessment of the EUNIS forest habitat probability maps. The comparison shows quite some similarities in range and distribution as well as some striking differences. Especially probability maps for EUNIS forest habitat types G2.6, G3.1b. G3.4a and G3.4b show a very low user accuracy, with respectively 7.4%, 2.2%, 13.9%, and 7.1%. Main reason seems to be the overestimation of the habitat type in the modelling approach. The actual range and distribution is much more limited. This overestimation is difficult to limit in the modelling steps. One solution might be that the use of e.g. the biogeographic regions, Atlas Flora Europaea (AFE) or the PNV (Potential Natural Vegetation) database as a filter that might enable us to reduce the range. However, in general, the overall accuracy is quite good for most produced EUNIS forest habitat probability maps. The overall accuracy is often better than the producer accuracy due to the fact that both the EUNIS habitat probability map and Natura 2000 habitat type according to the Article 17 database demonstrate absence in many regions. In general observations of presence are as important as observations of absence. Moreover, notice that the original EUNIS forest habitat probability maps have a spatial resolution of 20 m with an indication of the actual presence as a probability in percentages, and we can conclude that most EUNIS habitat maps, but not all maps, show a good result.

Table 3 Summary of validation of the modelled EUNIS forest habitat probability maps with habitat information from the Article 17 database.

Code	Name EUNIS forest habitat type	User accuracy	Producer accuracy	Overall accuracy
G1.1	Temperate and boreal softwood riparian woodland* [Riparian and gallery woodland, with dominant [Alnus], [Betula], [Populus] or [Salix]]	91.5%	59.9%	64.6%
G1.2	Temperate and boreal hardwood riparian woodland* [Mixed riparian floodplain and gallery woodland]	89.4%	69.4%	73.7%
G1.3	Mediterranean and Macaronesian riparian woodland* [Mediterranean riparian woodland]	75.0%	71.2%	87.6%
G1.5	Broadleaved swamp woodland on acid peat* [Broadleaved swamp woodland on acid peat]	66.9%	89.7%	77.3%
G1.6a	Fagus woodland on non-acid soils	87.9%	68.2%	84.1%
G1.6b	Fagus woodland on acid soils	68.5%	84.6%	80.7%
G1.7	Thermophilous deciduous woodland	65.8%	78.7%	78.5%
G1.8	Acidophilous Quercus woodland* [Acidophilous [Quercus]-dominated woodland]	54.4%	58.4%	76.8%

G1.9a	Mountain Betula and Populus tremula woodlands on mineral soils	65.5%	58.9%	83.9%
G1.A	Mesotrophic and eutrophic deciduous woodland, not dominated by Fagus* [Meso- and eutrophic [Quercus], [Carpinus], [Fraxinus], [Acer], [Tilia], [Ulmus] and related woodland]	87.1%	64.7%	75.0%
G2.1	Mediterranean evergreen Quercus woodland* [Mediterranean evergreen [Quercus] woodland]	75.8%	83.7%	91.2%
G2.6	Ilex aquifolium woodland* [[Ilex aquifolium] woods]	7.4%	77.1%	79.5%
G3.1a	Temperate mountain Picea woodland	63.9%	73.8%	93.5%
G3.1b	Temperate mountain Abies woodland	2.2%	10.9%	87.2%
G3.2	Temperate subalpine Larix-Pinus woodland* [Alpine [Larix] - [Pinus cembra] woodland]	48.9%	82.3%	96.7%
G3.4a	Temperate continental Pinus sylvestris woodland	13.9%	78.7%	67.6%
G3.4b	Temperate and submediterranean montane Pinus sylvestris-nigra woodland	7.1%	23.6%	75.4%
G3.7	Mediterranean lowland to submontane Pinus woodland* [Lowland to montane mediterranean [Pinus] woodland (excluding [Pinus nigra])]	29.0%	44.3%	83.8%
G3.9a	Taxus baccata woodland	8.5%	67.4%	70.0%
G3.E	Temperate bog conifer woodland* [Nemoral bog conifer woodland]	61.8%	36.7%	64.5%

References

Mücher, S., Hennekens, S., Schaminée, J., Halada, L., Halabuk, A., 2015. Modelling the spatial distribution of EUNIS forest habitats based on vegetation relevés and Copernicus HRL. Internal report ETC/BD.