

# HPDA Service for Estimating the Brown Bear (*Ursus arctos* L.) Population in Bulgaria



**EuroCC4SEE Workshop in Belgrade, 20 to 22 May 2025**

**EURO<sup>2</sup>**

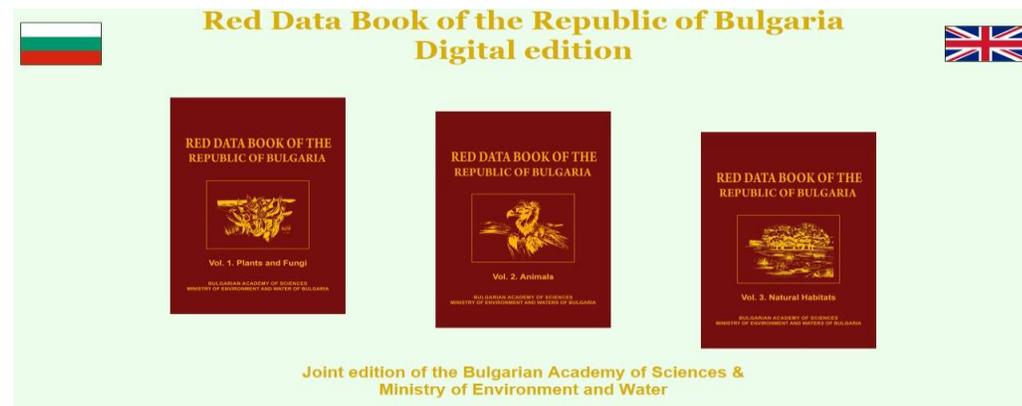
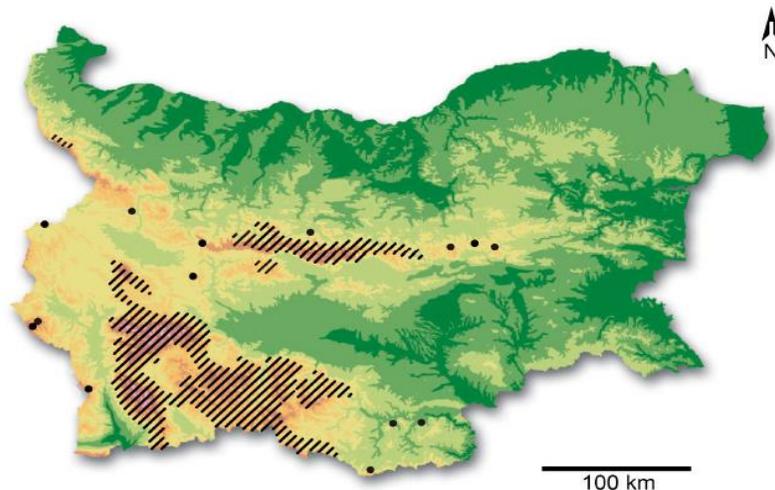
**Svetlozar Yordanov, IICT-BAS**

**(Todor Gurov, Emanouil Atanassov, Svetlozar Yordanov, Ruslan Serbezov, Silvi-Maria Gurova, Nikolai Spassov, and Radoslav Stanchev)**

*Institute of Information and Communication Technologies - BAS, National Museum of National History - BAS, Executive Environment Agency*

# Motivation

- The Habitat Directive requires strict protection of the species and the declaration of special protected areas for the conservation of its habitats.
- According to the IUCN Red List (<https://www.iucnredlist.org>), the mammals are more than 5000 species worldwide, 26% of them threatened with extinction.
- Brown Bear (*Ursus arctos*) is a priority species for the conservation of mammals in the European Union. Conservation status: in Bulgaria endangered EN [C2a (i)], BA-II, III, International: Beck-II; CITES-II; DH-II, IV.
- Red Data Book of the Republic Bulgaria, Vol. 2 – Animals, Sofia, 2011. <http://ecodb.bas.bg/rdb/en/>

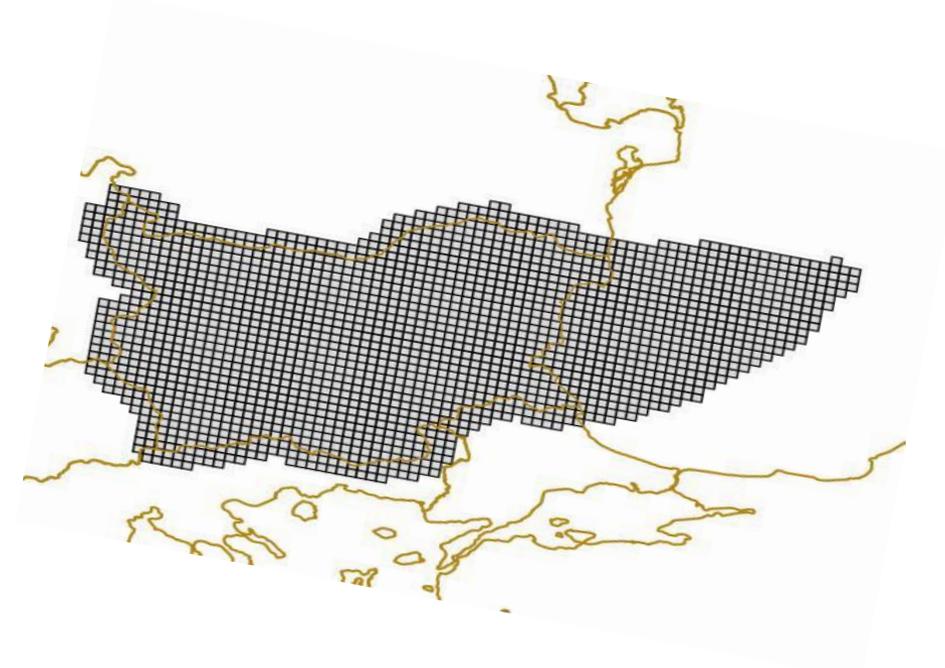
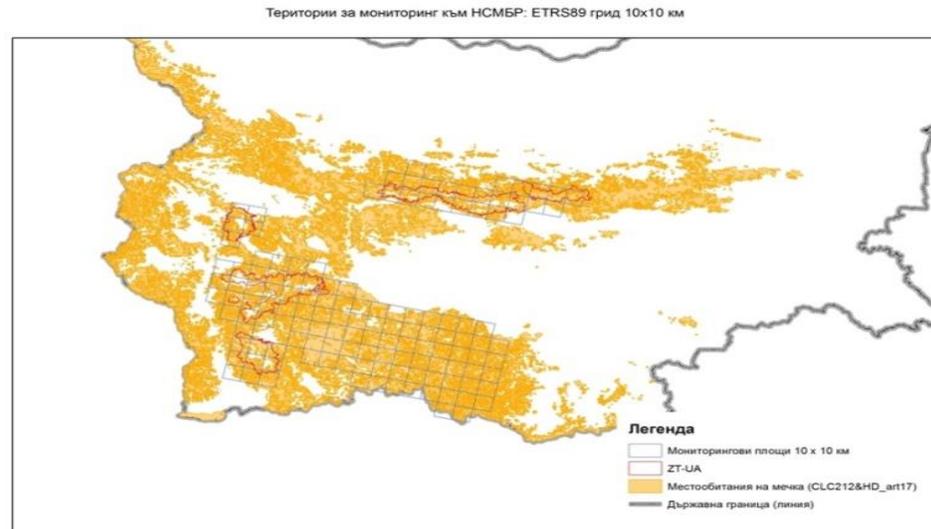


# National monitoring

National Monitoring at the main mountain's habitats (start since 2016):

- **Width/length of the front footprint and/or back footprint**
- **Excrements**
- **Found bear marking**
- **A place where the bear has fed itself**
- **Visual observation of a bear**
- **Found winter dens**
- **Bear bed**
- **GPS coordinates of all bear's traces/signs**

EUROPEAN TERRESTRIAL REFERENCE SYSTEM 89 (ETRS89),  
Grids 10x10 km



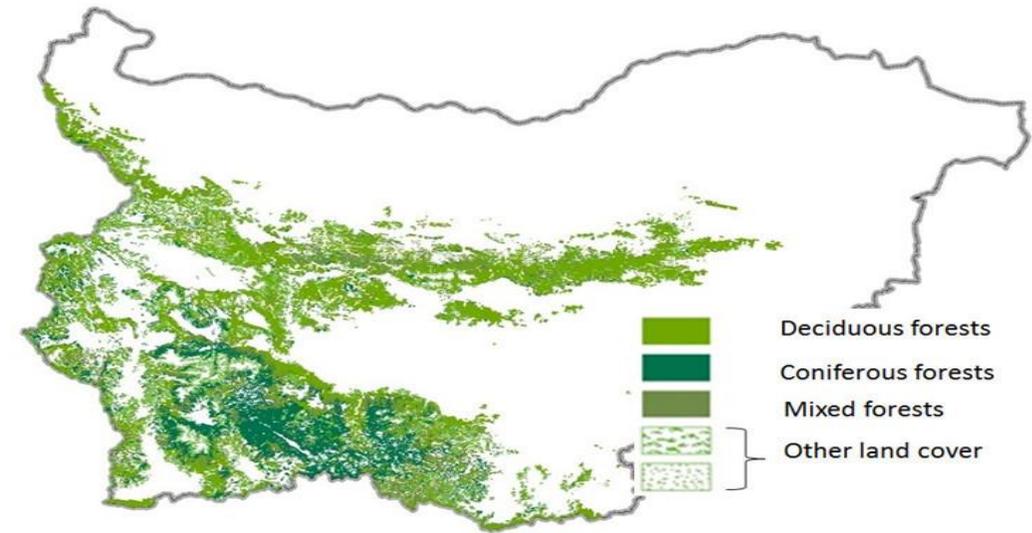
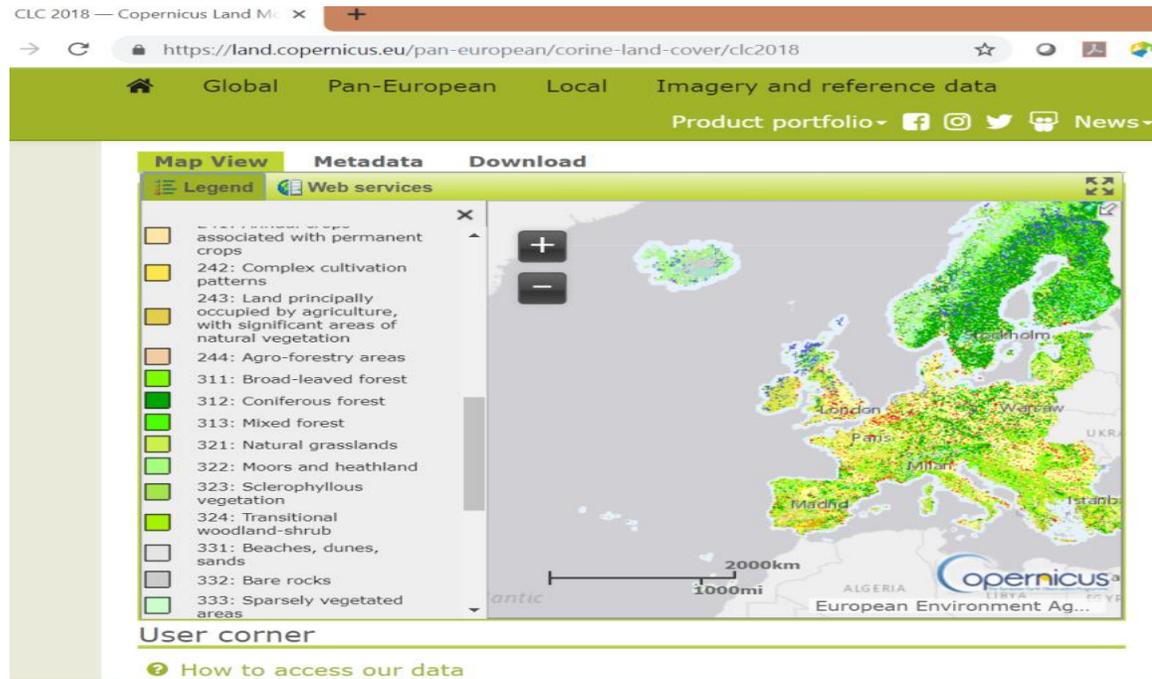
# Number of grids in each subpopulation area

Areas for Monitoring	ETRS89 Grids 10x10 km	Number
Vitosha-Verila-Plana	E541N226; E541N225; E540N226; E540N225; E540N224; E540N223; E541N223; E541N224; E542N224; E542N225	10
Rila	E540N220; E540N221; E540N222; E541N219; E541N220; E541N221; E541N222; E542N219; E542N220; E542N221; E542N222; E542N223; E543N219; E543N219; E543N220; E543N221; E543N222; E544N220; E544N221; E544N222; E544N223; E545N220; E545N221; E546N222; E545N223; E543N223	26
Pirin	E542N215; E542N216; E542N217; E542N218; E543N215; E543N216; E543N217; E544N215; E544N216; E544N217	10
Rhodops	E546N217; E547N222; E548N219; E552N218; E552N220; E556N220; E545N218; E545N219; E546N219; E546N220; E547N217; E547N220; E547N218; E547N219; E547N221; E548N217; E548N218; E548N220; E548N221; E549N216; E549N217; E549N218; E549N219; E549N220; E549N221; E550N216; E550N217; E550N218; E550N219; E550N220; E550N221; E551N216; E551N217; E551N218; E551N219; E551N220; E551N221; E552N216; E552N217; E552N219; E552N221; E553N216; E553N220; E554N220; E556N218; E553N217; E553N218; E553N219; E553N221; E554N215; E554N216; E554N217; E554N218; E554N219; E554N221; E555N215; E555N216; E555N217; E555N218; E555N219; E555N220; E555N221; E556N216; E556N217; E556N219; E545N220	60
Central Balkan	E555N229; E551N230; E547N229; E549N229; E549N230; E556N231; E557N230; E558N231; E548N229; E548N230; E549N231; E550N229; E550N230; E551N229; E552N229; E552N230; E553N229; E553N230; E554N229; E554N230; E554N231; E555N230; E555N231; E556N230; E557N231	25
Kotlen mountain	E564N233; E564N234; E565N234; E566N234	4

# CORINE Land Cover (CLC)



- CORINE Land Cover (CLC) is one of the most well-known and used products from the Copernicus Land Monitoring Service.
- It has previously been produced in 1990, 2000, 2006 and 2012 and now the **2018 edition** is available.



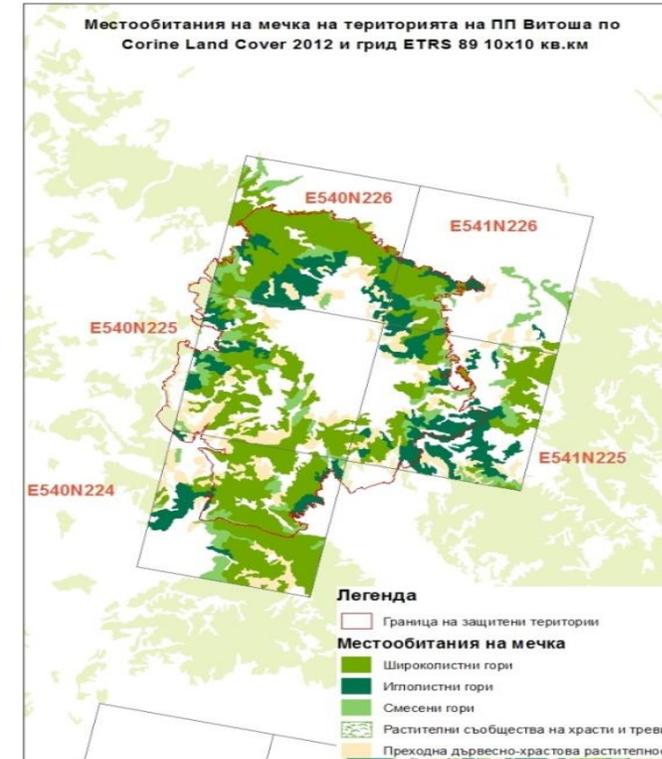
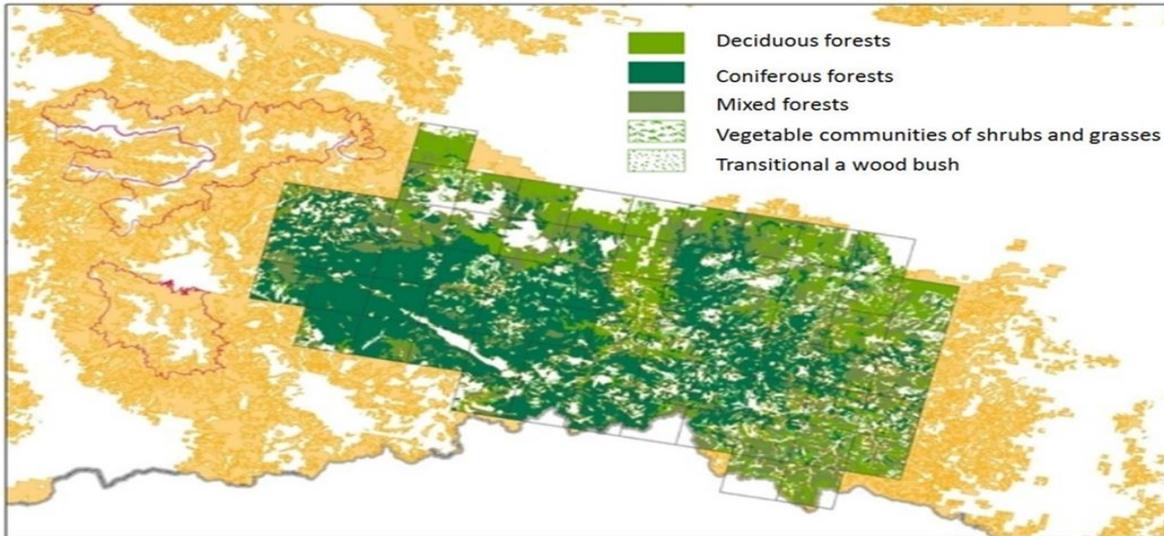
# Transect method

It is based on the collection of brown bear sign on predefined set of routes (transects) and the determination of the unique traces (especially footprints).

Statistical estimates for population size of the brown bears using data of national monitoring and developed HPDA service.

- **Type of the forests:**

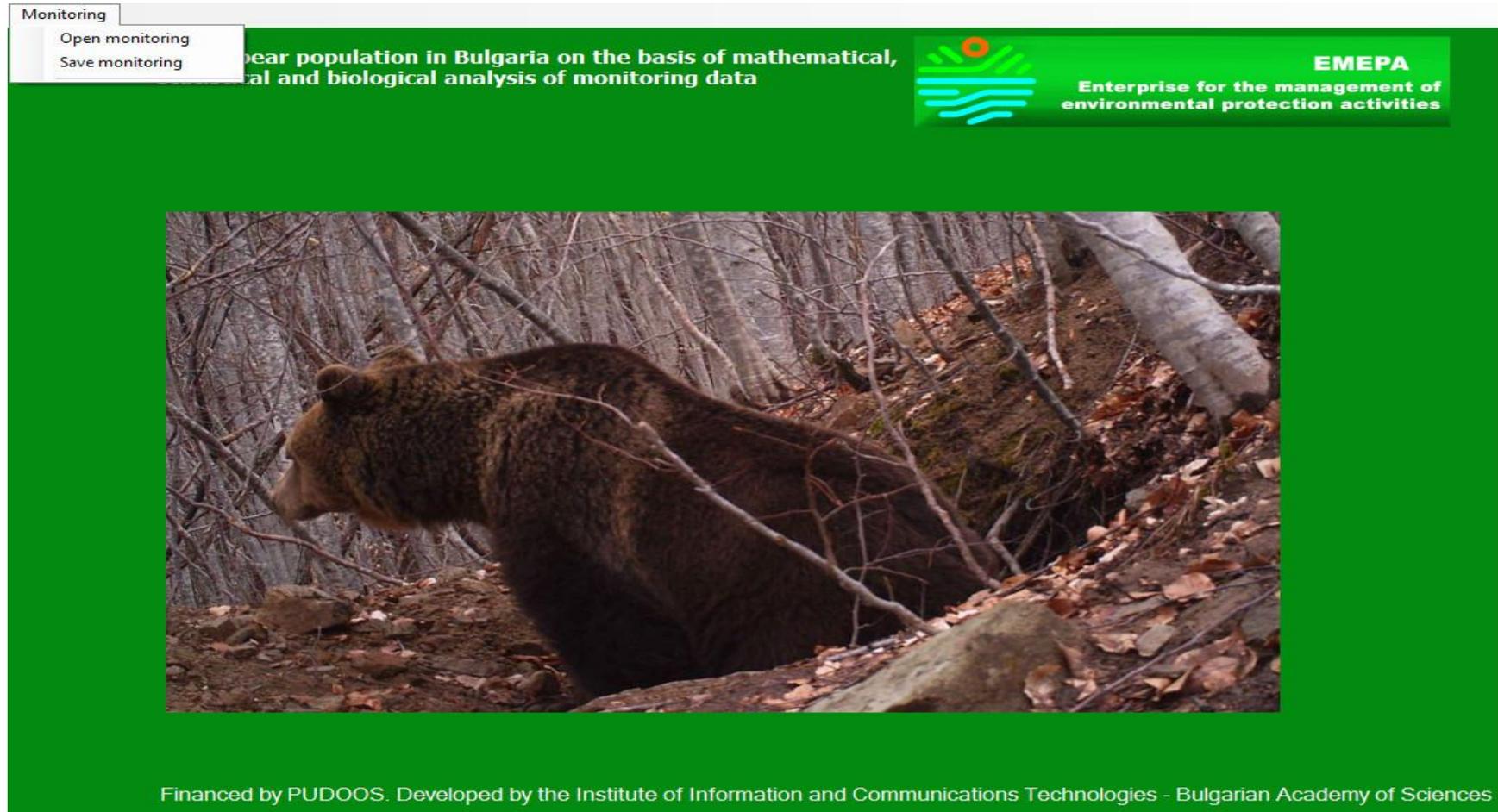
- **Deciduous forests** 311
- **Coniferous forests** 312
- **Mixed forests** 313
- **Vegetable communities of shrubs and grasses** 322
- **Transitional a wood bush** 324
- **Other land cover** no code



Bears' habitat for monitoring in the Western Rhodopes and Vitosha mounting

# Start of the HPDA service

- Input the monitoring data to start the preproduction process

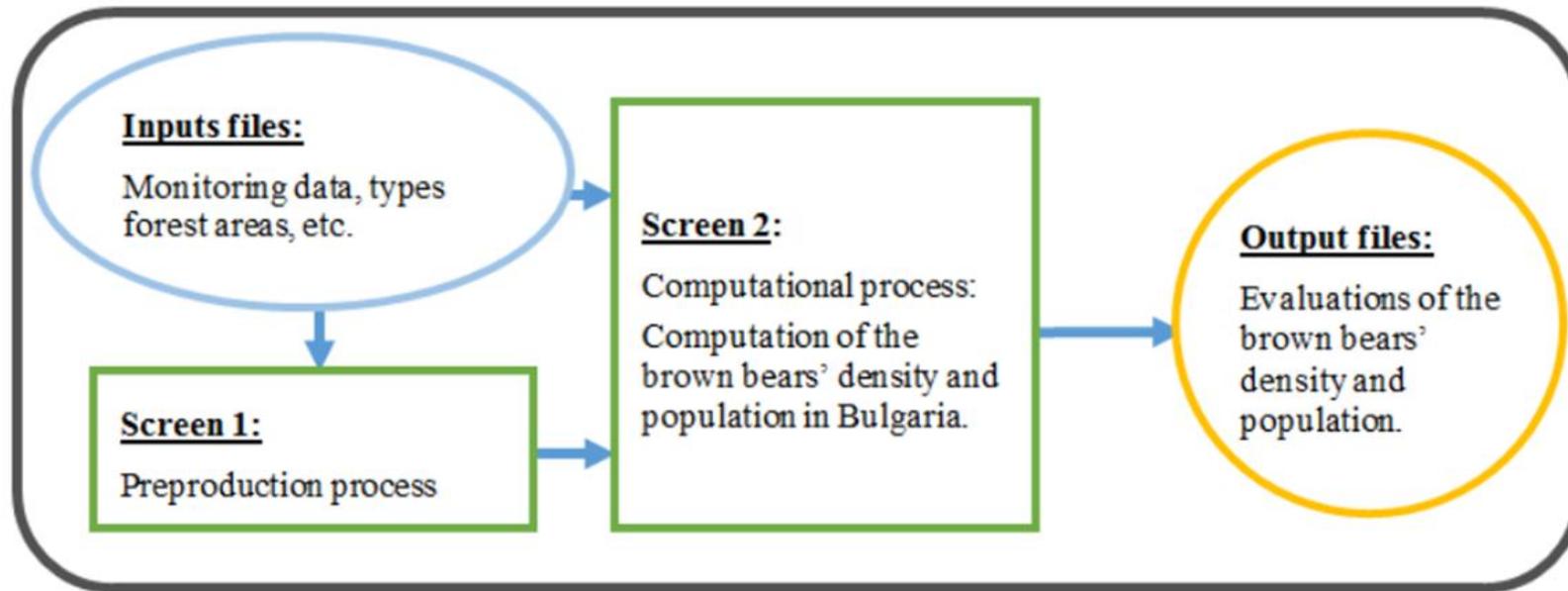


The screenshot shows a web application interface with a green header. On the left, there is a 'Monitoring' menu with options 'Open monitoring' and 'Save monitoring'. The main header text reads 'Bear population in Bulgaria on the basis of mathematical, statistical and biological analysis of monitoring data'. To the right of the text is the EMEPA logo, which consists of a stylized sun and waves, with the text 'EMEPA Enterprise for the management of environmental protection activities'. Below the header is a large photograph of a brown bear in a forest. At the bottom of the interface, there is a footer text: 'Financed by PUDOOS. Developed by the Institute of Information and Communications Technologies - Bulgarian Academy of Sciences'.

# Estimation of the population size of the brown bears (1/2)

The evaluation is done in two steps.

**First step:** Identify unique traces based on collected observations in the national monitoring. The number of unique traces is determined by experts using the developed software product. Once the unique number of traces has been obtained, the program automatically allocates them by number in the respective 5 types of forest and in the residual area.



# Input File - 1

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
FID	Shape	Label	Form_ID	Form_Name	Date	Type	Width	Length	Width	Length	Soil_Type_0	Notes	X	Y
9	Point	00015	00015200001000075930	Brown bear	19.5.2015	Trace	16,00	15,00			mud	Both t	24,9541	42,6844
85	Point	00016	00016900001000002133	Brown bear	6.11.2015	Trace			11,00	20	Sand		24,8983	41,7569
84	Point	00015	00015400001000023854	Brown bear	5.11.2015	Trace							23,4342	42,0336
83	Point	00015	00015400001000023945	Brown bear	4.11.2015	Trace	13,00		14,00	21	mud	Conifer	23,5423	42,0587
82	Point	00015	00015400001000023697	Brown bear	5.11.2015	Trace	9,00		9,00	18	Soil	Fresh	23,395	41,976
81	Point	00015	00015400001000023470	Brown bear	5.11.2015	Trace	12,00				Sand, Fresh	Conifer	23,2401	42,0763
80	Point	00015	00015200001000087813	Brown bear	13.10.2015	Trace	12,00		11,00	16	Sand		24,4501	42,785
8	Point	00015	00015200001000080184	Brown bear	5.11.2015	Trace			12,00	23	Soil	meadow	24,493	42,7529
79	Point	00014	00014100001000001027	Brown bear	4.11.2015	Trace	11,00				mud		24,0796	41,9304
78	Point	00014	00014100001000001027	Brown bear	4.11.2015	Trace	11,00				mud		24,0738	41,9304
77	Point	00015	00015400001000015827	Brown bear	5.11.2015	Trace	12,00				Sand		23,2401	42,0763
76	Point	00015	00015200001000078738	Brown bear	4.11.2015	Trace	12,00	11,00					24,8236	42,7562
75	Point	00015	00015200001000087753	Brown bear	20.5.2015	Trace	13,00	13,20			mud. Beech		24,9464	42,7775
74	Point	00015	00015200001000087393	Brown bear	20.5.2015	Trace	10	10			Soil in Beech		24,9614	42,7567
73	Point	00015	00015200001000089717	Brown bear	8.8.2015	Trace							25,1394	42,6713
72	Point	00015	00015200001000083544	Brown bear	4.12.2015	Trace							24,3603	42,7651
71	Point	00011	00011500001000005847	Brown bear	4.11.2015	Trace				23	Sand		23,9724	41,9324
70	Point	00011	00011500001000005847	Brown bear	4.11.2015	Trace			13,5	23	Sand		23,9731	41,9309
7	Point	00015	00015200001000075466	Brown bear	19.5.2015	Trace	17		17	24	mud	Trace i	24,4956	42,7593
69	Point	00011	00011500001000005847	Brown bear	4.11.2015	Trace			14	21	Sand		23,9858	41,9198
68	Point	00011	00011500001000005847	Brown bear	4.11.2015	Trace			14		Sand		23,9848	41,9187
67	Point	00011	00011500001000005847	Brown bear	4.11.2015	Trace	15		15	22	Sand		23,9879	41,917

# Input file -2

Code for each grid  
(10x10 km) according to:

- Code of the mountain
- Type of areas in hectares

	A	B	C	D	E	F	G	H	I	J
1	Area	Mountain	Alpine or continental region	311	312	313	322	324	Sum	Other
2	E547N229	1	2	2445	134	4355	290	526	7750	2250
3	E548N229	1	2	1807	779	1831	396	270	5083	4917
4	E548N230	1	2	3820	199	2648	0	1077	7744	2256
5	E549N229	1	2	1719	581	2887	785	395	6367	3633
6	E549N230	1	2	4501	0	3871	0	384	8756	1244
7	E549N231	1	2	4904	211	2506	0	686	8307	1693
8	E550N229	1	2	3185	276	3030	0	449	6940	3060
9	E550N230	1	2	2622	0	4344	0	719	7685	2315
10	E551N229	1	2	2163	0	1769	55	460	4447	5553
11	E551N230	1	2	2611	77	3250	0	450	6388	3612
12	E552N229	1	2	2925	781	645	358	1633	6342	3658
13	E552N230	1	2	5354	0	3048	339	139	8880	1120
14	E553N229	1	2	1912	315	571	422	1686	4906	5094
15	E553N230	1	2	4825	252	1561	0	1162	7800	2200
16	E554N229	1	2	4800	55	1026	0	1213	7094	2906
17	E554N230	1	2	3606	17	1812	916	250	6601	3399
18	E554N231	1	2	2258	262	2788	0	300	5608	4392
19	E555N229	1	2	1259	31	348	0	356	1994	8006
20	E555N230	1	2	5720	0	1612	73	116	7521	2479
21	E555N231	1	2	4903	173	3551	0	351	8978	1022
22	E556N230	1	2	4892	13	586	0	521	6012	3988
23	E556N231	1	2	5910	243	1482	0	368	8003	1997
24	E557N230	1	2	2649	336	1176	0	264	4425	5575
25	E557N231	1	2	6658	26	1520	0	101	8305	1695
26	E558N231	1	2	6030	200	2533	0	223	8986	1014
27	E540N223	5	1	2251	974	569	0	946	4740	5260
28	E541N223	5	1	3875	523	761	0	617	5776	4224
29	E545N218	2	1	311	5718	2072	0	1046	9147	853

# Preproduction process: Define the unique traces

Estimate of brown bear population in Bulgaria on the basis of mathematical, statistical and biological analysis of monitoring data



Enterprise for the management of environmental protection

Bears Results

FID	Shape	Label	Form_ID	Form_N:	Date	Type	Width_n	Length_	Width_n	Length_	Soil_Typ	Notes	X	Y	Forest Type	Area	Delete	Skip	Select
65	Point	00011...	00011...	Brown...	4.11.2...	Trace	14						23.9912	41.9163	Conif...	E547...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
42	Point	00011...	00011...	Brown...	4.11.2...	Trace		12	20				24.0041	41.8688	Conif...	E548...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
78	Point	00014...	00014...	Brown...	4.11.2...	Trace	11				mud		24.0738	41.9304	Mixed...	E548...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
79	Point	00014...	00014...	Brown...	4.11.2...	Trace	11				mud		24.0796	41.9304	Mixed...	E548...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
0	Point	00012...	00012...	Brown...	4.11.2...	Trace	11		10	20	Sandy...	Conif...	24.0888	41.8902	Other	E548...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
27	Point	00011...	00011...	Brown...	4.11.2...	Trace					grass	The tr...	24.0905	41.7833	Conif...	E548...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Point	00012...	00012...	Brown...	4.11.2...	Trace	11				mud, ...	Conif...	24.1292	41.9036	Conif...	E548...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
25	Point	00011...	00011...	Brown...	4.11.2...	Trace	14						24.1513	41.8825	Mixed...	E549...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
24	Point	00011...	00011...	Brown...	4.11.2...	Trace	19						24.1513	41.8825	Mixed...	E549...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20	Point	00012...	00012...	Brown...	4.11.2...	Trace	11		10	18	mud, ...	Conif...	24.1521	41.8951	Other	E549...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
21	Point	00012...	00012...	Brown...	4.11.2...	Trace	12		11	19	mud, ...	Conif...	24.1793	41.898	Mixed...	E549...	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
29	Point	00011...	00011...	Brown...	4.11.2...	Trace							24.1798	42.0692	Mixed...	E549...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
33	Point	00011...	00011...	Brown...	4.11.2...	Trace	13		11	18	mud	Old Tr...	24.207	41.8057	Conif...	E549...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
34	Point	00011...	00011...	Brown...	4.11.2...	Trace	13		10	18	Sand	Fresh ...	24.221	41.8083	Other	E549...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
53	Point	00011...	00011...	Brown...	5.11.2...	Trace	12				Sand		24.3186	41.7337	Other	E550...	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
52	Point	00011...	00011...	Brown...	5.11.2...	Trace	14		15	23	Sand		24.3196	41.7334	Other	E550...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
54	Point	00011...	00011...	Brown...	5.11.2...	Trace	10				mud		24.3335	41.728	Conif...	E551...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
17	Point	00015...	00015...	Brown...	4.11.2...	Trace							24.3522	42.7819	Veget...	E549...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
63	Point	00011...	00011...	Brown...	5.11.2...	Trace	14						24.3588	41.8092	Conif...	E551...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
72	Point	00015...	00015...	Brown...	4.12.2...	Trace							24.3603	42.7651	Veget...	E549...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
43	Point	00015...	00015...	Brown...	4.12.2...	Trace							24.3665	42.7618	Transi...	E549...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
59	Point	00012...	00012...	Brown...	4.11.2...	Trace	12		12	19	old mud	Mixed...	24.3758	41.8837	Mixed...	E551...	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
58	Point	00011...	00011...	Brown...	4.11.2...	Trace	12		12	19	mud	old	24.3758	41.8837	Mixed...	E551...	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
37	Point	00012...	00012...	Brown...	5.11.2...	Trace							24.381	41.595	Other	E551...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
38	Point	00012...	00012...	Brown...	5.11.2...	Trace							24.388	41.631	Decid...	E551...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
22	Point	00011...	00011...	Brown...	6.11.2...	Trace	10				Forest...		24.4833	41.6103	Other	E552...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8	Point	00015...	00015...	Brown...	5.11.2...	Trace		12	23		Soil	mead...	24.493	42.7529	Decid...	E550...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Distance between traces    Show on map    Delete traces    Re-color    Re-count forests

Forest type	Count
Total	68
Other	12
324 - Transitional ...	1
322 - Vegetable c...	4
313 - Mixed forest	26
312 - Coniferous f...	15
311 - Deciduous f...	10

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# Skipping, re-coloring and re-counting

Monitoring

Estimate of brown bear population in Bulgaria on the basis of mathematical, statistical and biological analysis of monitoring data

EMEPA  
Enterprise for the management of environmental protection activities

Bears Results

FID	Shape	Label	Form_ID	Form_N	Date	Type	Width_n	Length_n	Width_n	Length_n	Soil_Typ	Notes	X	Y	Forest Type	Area	Delete	Skip	Select
24	Point	00011...	00011...	Brown...	4.11.2...	Trace	19						24.1513	41.8825	Mixed...	E549...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20	Point	00012...	00012...	Brown...	4.11.2...	Trace	11	10	18	mud...	Conif...		24.1521	41.8951	Other	E549...	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
21	Point	00012...	00012...	Brown...	4.11.2...	Trace	12	11	19	mud...	Conif...		24.1793	41.898	Mixed...	E549...	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
29	Point	00011...	00011...	Brown...	4.11.2...	Trace							24.1798	42.0692	Mixed...	E549...	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
33	Point	00011...	00011...	Brown...	4.11.2...	Trace	13	11	18	mud	Old Tr...		24.207	41.8057	Conif...	E549...	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
53	Point	00011...	00011...	Brown...	5.11.2...	Trace	12			Sand			24.3186	41.7337	Other	E550...	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
52	Point	00011...	00011...	Brown...	5.11.2...	Trace	14	15	23	Sand			24.3196	41.7334	Other	E550...	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
54	Point	00011...	00011...	Brown...	5.11.2...	Trace	10			mud			24.3335	41.728	Conif...	E551...	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
17	Point	00015...	00015...	Brown...	4.11.2...	Trace							24.3522	42.7819	Veget...	E549...	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
63	Point	00011...	00011...	Brown...	5.11.2...	Trace	14						24.3588	41.8092	Conif...	E551...	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
72	Point	00015...	00015...	Brown...	4.12.2...	Trace							24.3603	42.7651	Veget...	E549...	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
43	Point	00015...	00015...	Brown...	4.12.2...	Trace							24.3665	42.7618	Transi...	E549...	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
59	Point	00012...	00012...	Brown...	4.11.2...	Trace	12	12	19	old mud	Mixed...		24.3758	41.8837	Mixed...	E551...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
37	Point	00012...	00012...	Brown...	5.11.2...	Trace							24.381	41.595	Other	E551...	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
38	Point	00012...	00012...	Brown...	5.11.2...	Trace							24.388	41.631	Decid...	E551...	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
22	Point	00011...	00011...	Brown...	6.11.2...	Trace	10			Forest...			24.4833	41.6103	Other	E552...	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
8	Point	00015...	00015...	Brown...	5.11.2...	Trace		12	23	Soil	mead...		24.493	42.7529	Decid...	E550...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
26	Point	00011...	00011...	Brown...	5.11.2...	Trace	10						24.5413	41.7865	Conif...	E552...	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
23	Point	00011...	00011...	Brown...	4.11.2...	Trace	12	10		Forest...	trace		24.553	41.93	Conif...	E552...	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
56	Point	00011...	00011...	Brown...	6.11.2...	Trace	10	12					24.5824	41.6789	Other	E553...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
55	Point	00011...	00011...	Brown...	4.11.2...	Trace	13						24.5873	41.9402	Conif...	E552...	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
62	Point	00015...	00015...	Brown...	4.11.2...	Trace							24.7404	42.838	Veget...	E552...	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
76	Point	00015...	00015...	Brown...	4.11.2...	Trace	12	11					24.8236	42.7562	Mixed...	E552...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
61	Point	00015...	00015...	Brown...	4.11.2...	Trace	12	10		mud	The s...		24.8462	42.7447	Decid...	E553...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
30	Point	00011...	00011...	Brown...	6.11.2...	Trace	13						24.8505	41.781	Decid...	E555...	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
31	Point	00011...	00011...	Brown...	6.11.2...	Trace	15	9	17	Soil			24.8506	41.781	Decid...	E555...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
32	Point	00011...	00011...	Brown...	6.11.2...	Trace				mud			24.8512	41.7793	Mixed...	E555...	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Distance between traces    Show on map    Delete traces    Re-color    Re-count forests

Forest type	Count
311 - Deciduous f...	9
312 - Coniferous f...	14
313 - Mixed forest	21
322 - Vegetable c...	4
324 - Transitional ...	1
Other	11
Total	60

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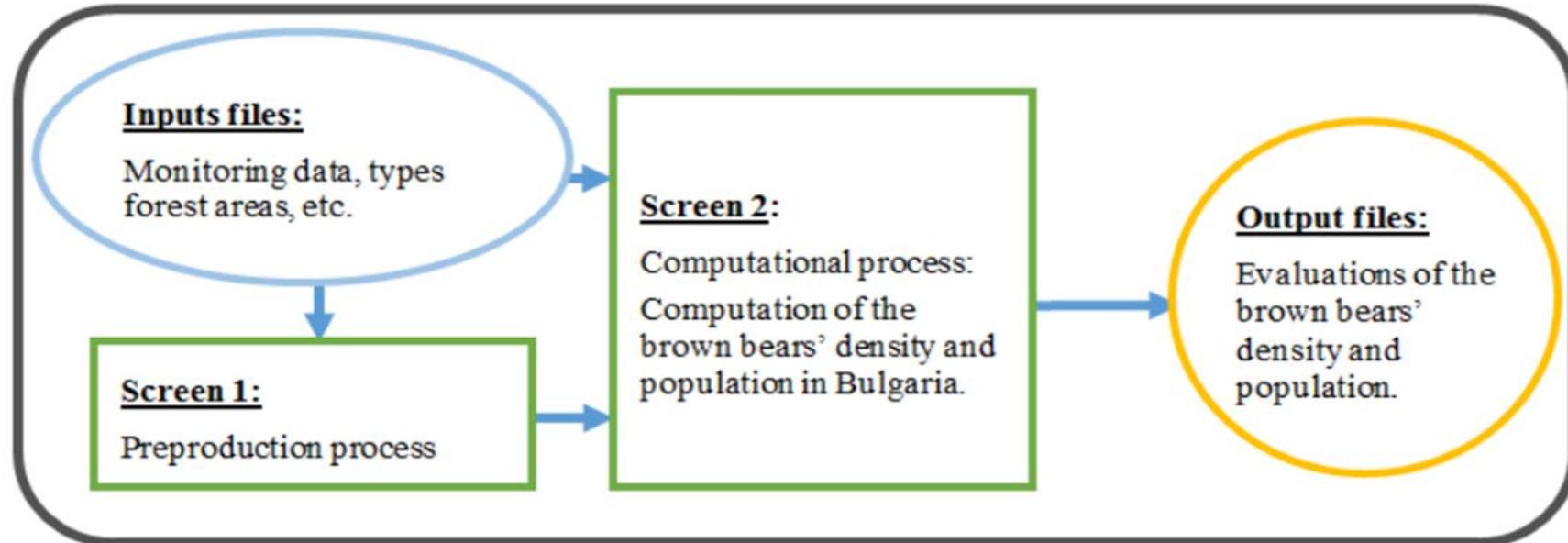
# Estimation of the population size of the brown bears

**Second step:** At this stage, the program statistically estimates the number of population and the distribution density of the brown bear on the 6 geographic areas (mountains) and on two geographic climatic areas (alpine and continental).

Since there are not enough 232 transects covering all 142 grids during the national monitoring, the program automatically divides the number of grids into **two sets**.

**The first set** includes those grids which contain transects (grids) visited during the national monitoring. The number of the brown bear is estimated statistically using the **maximum likelihood method**.

**The second set** includes those grids which contain transects (grids), not visited during the national monitoring. The number of population in the second set is obtained by extrapolation.



# Computational process

- Computation of the density and the population of the species

Estimate of brown bear population in Bulgaria on the basis of mathematical, statistical and biological analysis of monitoring data

Executive Environment Agency

Bears Results

Open areas Save areas

ETRS	visited	Mountain	Number
E543N216	no	Pirin	not visited
E543N217	yes	Pirin	1
E543N219	yes	Rila	1
E543N220	yes	Rila	3
E543N221	yes	Rila	1
E543N222	yes	Rila	1
E543N223	no	Rila	not visited
E544N215	no	Pirin	not visited

Accuracy: 10000 All monitoring-2017 Calculate

Mountain	Estimate	Lower boundary	Upper boundary
Stara Planina	72.99	49.64	96.34
Western Rhodopes	209.8	169.33	250.28
Rila	69.89	58.12	81.67
Pirin	35.46	31.34	39.58
Vitosha	23.06	23.06	23.06
Kotlenska Planina	8.75	7.52	9.99
Verila	13.13	12.41	13.86
Plana	6.28	6.28	6.28
Alpine region	385.43	316.4	454.46

Show age structure Age structure by marks Calculate with threats Reference values

Reference values for the main local populations of the brown bear

Level:	Favorable	Unfavorable - unsatisfactory	Unfavorable - bad	Large population of brown bear
<b>Brown bear habitat</b>				
<b>Population of the brown bear in the sample areas on the territory of Bulgaria</b>	420 - 690	370-419	Under 370	Over 691
<b>Central Balkan</b>	130 - 180	80 - 129	Under 80	Over 181
<b>Western Rhodopes</b>	140 - 220	120 - 139	Under 120	Over 221
<b>Rila</b>	70 - 125	48 - 69	Under 48	Over 126
<b>Pirin</b>	40 - 95	30 - 39	Under 30	Over 96
<b>Vitosha</b>	9 - 13	6 - 9	Under 6	Over 14
<b>Plana</b>	4 - 6	2 - 3	Under 2	Over 7
<b>Verila</b>	5 - 8	2 - 4	Under 2	Over 9
<b>Kotlen mountain</b>	7 - 10	3 - 6	Under 3	Over 11
<b>Alpine biogeographical region</b>	397-650	353-397	Under 353	Over 651
<b>Continental biogeographical region</b>	23 - 40	15 - 22	Under 15	Over 41

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# Statistical estimation of the bears' population

- We use maximum likelihood method with following parameters.
- We have introduced the **coefficients**  $\lambda_1, \dots, \lambda_5$ , to estimate the probability of detecting the presence of a bear in a given area (forest type), which are the parameters of the Poisson distribution (assumed the distribution is Poisson).
- These parameters describe the number of bears per unit area in the respective forest type.
- We have also introduced **the coefficients**  $\psi_1, \dots, \psi_5$ , which correspond to the probability of finding a bear if it is in the relevant area (grid) and type of forest.

$$P(i, j, d) = e^{-\lambda_j} \sum_{k=d}^{\infty} \binom{k}{d} \psi_i^d (1 - \psi_j)^{k-d} \psi_j^d (1 - \psi_j)^{k-d} \frac{\lambda_j^k}{k!}$$

- **Using these coefficients, we have constructed a likelihood function.**
- When  $\psi_j = 1$ , (in case we have forest animal feeders in the each grid) we obtain simpler formula:  
$$e^{-\lambda_j} \frac{\lambda_j^d}{d!},$$
 where  $d$  is the number of the unique traces.
- Using **maximum likelihood estimation we can** estimate the values of the **coefficients**  $\lambda_1, \dots, \lambda_5$ , and  $\psi_1, \dots, \psi_5$ .

# Age structures by unique traces

Estimate of brown bear population in Bulgaria on the basis of mathematical, statistical and biological analysis of monitoring data

Executive Environment Agency

Bears Results

Open areas Save areas Load areas Save distribution

ETRS	visited	Mountain	Number of traces
E543N216	no	Pirin	not visited
E543N217	yes	Pirin	1
E543N219	yes		
E543N220	yes		
E543N221	yes		
E543N222	yes		
E543N223	no		
E544N215	no		

Mountain	Number of traces
Kotlenska Planina	0
Pirin	3

Accuracy 10000 All

Mountain	Estimate
Stara Planina	72.99
Western Rhodopes	209.8
Rila	69.89
Pirin	35.46
Vitosha	23.06
Kotlenska Planina	8.75
Verila	13.13
Plana	6.28
Alpine region	385.43

Age structure by number of marks

Mountain	Bear up to one year	Bear up to two years	Young female / Young Male	Mature female / Immature Male	Mature male	Adult bear	Total
Rila	1.28	1.64	6.8	5.92	1.12	1.24	
Verila	0	0	0	0	0	0	
Vitosha	0	0	2	1	0	0	
Pirin	0.16	0.08	1.35	0.24	1.14	0.03	
Plana	0	0	0	0	0	0	
Western Rhodopes	2.12	2.56	22.45	10.68	4.98	1.21	
Stara Planina	2.76	0.88	4.85	6.64	2.54	0.33	
Kotlenska Planina	0	0	0	0	0	0	
Alpine	6.16	5.08	34.1	23.24	8.64	2.78	80
Continental	0.16	0.08	3.35	1.24	1.14	0.03	6
Total	6.32	5.16	37.45	24.48	9.78	2.81	86

Show age structure Age structure by marks Calculate with threats Reference values Save distribution

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# Table for Age Structure

**Table:** Size of the footprints of the brown bear from Bulgaria and Eastern Europe. Correlation between the length of the footprint of the hind paw, the width of the fore one, and the size, the sex and the age of the bear.

Feature	Width of the fore paw footprint	Width of the hind paw footprint	Length of the hind paw footprint
<b>Category bear</b>			
<b>1. A bear cub – 1<sup>st</sup> year</b>	<b>5-7 cm</b>	<b>-</b>	<b>6-11 cm</b>
<b>2. A bear cub – 2<sup>nd</sup> year, up to ~ 50 kg.</b>	<b>~ 8-9 \10</b>	<b>0-0.5 cm narrower than the anterior one</b>	<b>12-15</b>
<b>3. Young females (3 and 4 years' old) and young males ~ 3 years' old (small bear: ~ 50-100 kg)</b>	<b>10/11-12 cm.</b> (the most frequent in the field) In the young individuals with 12 cm are most possibly young males because 12 cm is normal size for a mature female)	<b>0-0.5 cm. narrower than the anterior</b>	<b>16-19/20</b>
<b>4. Adult females and subadult ( 4-5 years old) males (average-sized bear - 100 ~ 200 kg.)</b>	<b>12/13-13.5/14; (extremely rarely 14 cm – for a female but most frequently for a young male)</b>	<b>~ 0.5-1 cm Narrower than the anterior</b>	<b>19/20-23/24 cm;</b> (23/24 – only male individuals)
<b>5. Mature males more than 5 years old (large bear ~ 200-250 kg)</b>	<b>14.5-17</b>	<b>It could be up to 1-1.5 cm narrower</b>	<b>24-26/27</b>
<b>6. Very big, old males, usually more than 10 years' old and more than 250 kg (records – above 350 kg)</b>	<b>17 and more</b>	<b>Up to 1-2 cm narrower</b>	<b>27-30 (31?) cm</b>

# Age structures of the estimated population

Estimate of brown bear population in Bulgaria on the basis of mathematical, statistical and biological analysis of monitoring data

Executive Environment Agency

Bears Results

Open areas Save areas Load areas Save distribution

Age structure of the population

Mountain	Bear up to one year	Bear up to two years	Young female / Young Male	Mature female / Immature Male	Mature male	Adult bear
Rila	4.88	4.88	30.12	20.35	8.14	1.63
Verila	0.91	0.91	5.59	3.78	1.51	0.3
Vitosha	1.6	1.6	9.9	6.69	2.67	0.53
Pirin	2.51	2.51	15.49	10.47	4.19	0.84
Plana	0.42	0.42	2.58	1.74	0.7	0.14
Western Rhodopes	14.72	14.72	90.78	61.34	24.53	4.91
Stara Planina	5.09	5.09	31.41	21.22	8.49	1.7
Kotlenska Planina	0.63	0.63	3.87	2.62	1.05	0.21
<b>Total</b>	<b>30.77</b>	<b>30.77</b>	<b>189.73</b>	<b>128.2</b>	<b>51.28</b>	<b>10.26</b>
Alpine region	27.01	27.01	166.56	112.54	45.02	9
Continental region	3.64	3.64	22.45	15.17	6.07	1.21
<b>Theoretical value in %</b>	<b>16%</b>	<b>8%</b>	<b>35%</b>	<b>24%</b>	<b>14%</b>	<b>3%</b>
General theoretical distr...	70.56	35.28	154.35	105.84	61.74	13.23

Accuracy 10000 All

Mountain	Estimate
Stara Planina	72.99
Western Rhodopes	209.8
Rila	69.89
Pirin	35.46
Vitosha	23.06
Kotlenska Planina	8.75
Verila	13.13
Plana	6.28
Alpine region	385.43

316.4 454.46 Favorable Pirin 4.2

Show age structure Age structure by marks Calculate with threats Reference values

Save

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# List of pressures and threats

Pressures and Threats	weight	Favorable	Unfavorable - unsatisfactory	Unfavorable - bad
Derogation of problematic bears	L	0 - 25%	25 - 40%	Over 40%
Conflicts with farmers and local people	H	0-10%	11-30%	Over 30%
Poaching	H	0-10%	11-30%	Over 30%
Disturbance (human activities)	M	0 - 20%	21 - 50%	Over 50%
Destructions of bio-corridors	H	0-10%	11-30%	Over 30%
Natural threats (survival of bears up to two years of age)	L	0 - 60%	60-70%	Over 70%
Forest management for reduction ( reduction of the area) of old forests	H	0-10%	11-30%	Over 30%
Sports infrastructure and tourism infrastructure	M	0 - 20%	21 - 50%	Over 50%
Climate change	M	0 - 20%	21 - 50%	Over 30%

# Formula for computing the accumulated tread

- Justification for the choice of certain parameters: reflects the adverse effects on the condition and threats to the species in the studied habitats.
- Method of calculation:

$$F(\%) = \frac{n * (1 - \mu)}{N} * 100,$$

where  $n$  - means the number of sample areas (grids 10x10 km) in which the threat/impact is registered, and  $N$  - total number of sample areas in the studied habitats for a given level of analysis, and  $\mu$  is an weight parameter depending on the degree of significance of the threat ( $L$  = low significance,  $M$  = medium significance,  $H$  = high significance.  $\mu$  is belong to  $(0,1)$ ).

For example: when we have  $H$  (high significance),  $\mu \approx 0,90$ ; if we have  $M$ ,  $\mu \approx 0,50$ , and when we have  $L$  (low significance),  $\mu \approx 0,20$ .

- The integrated threat is calculated in percentages according to the formula:

$$F(\%) = \sum_{i=1}^k \frac{n_i * (1 - \mu_i)}{N} * 100.$$

# Calculate with threats

Estimate of brown bear population in Bulgaria on the basis of mathematical, statistical and biological analysis of monitoring data



Bears Results

Open areas Save areas Load areas Save distribution

ETRS	visited	Mountain	Number of traces
E543N216	no	Pirin	not visited
E543N217	yes	Pirin	1
E543N219	yes		
E543N220	yes		
E543N221	yes		
E543N222	yes		
E543N223	no		
E544N215	no		

Mountain	Number of traces
Kotlenska Planina	0
Pirin	3

Accuracy: 10000 All monitoring-2017

Mountain	Estimate	Lower bound
Stara Planina	72.99	49.64
Western Rhodopes	209.8	169.33
Rila	69.89	58.12
Piril	35.46	31.34
Vitosha	23.06	23.06
Kotlenska Planina	8.75	7.52
Verila	13.13	12.41
Plana	6.28	6.28
Alpine region	385.43	316.4

**Threats**

Threats

Derogation of problematic bears

Conflicts with farmers and local people

Poaching

Disturbance (human activities)

Destruction of biocorridors

Natural threats (survival of bears up to two years of age)

Forest management for reduction (reduction of the area) of old forests

Sports infrastructure and tourism infrastructure

Climate change

Weight	Count	Influence
L		
H		
H		
M		
H		
L		
H		
M		
M		

Calculate

Rila	4.1
Pirin	4.2

Show age structure Age structure by marks **Calculate with threats** Reference values

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# Created unique traces using the data of given monitoring

Mountain	Number of unique traces 2017	Number of unique traces 2018	Number of unique traces 2019	Number of unique traces 2020
Central Balkan	10	8	11	7
Western Rhodopes	38	49	50	47
Rila	11	11	9	21
Pirin	6	2	3	5
Kotlen mountain	1	0	1	0
Plana, Verila, Vitosha	2	1	3	1
Alpine area	60	68	71	75
Continental area	8	3	6	6
<b>Total</b>	<b>68</b>	<b>71</b>	<b>77</b>	<b>81</b>

# Evaluation results using HPDA service



Mountain	2017	2018	2019	2020
Central Balkan	61	61	58	77
Western Rhodopes	200	185	185	229
Rila	70	84	59	93
Pirin	37	40	41	35
Kotlen mountain	6	2	8	5
Plana, Verila, Vitosha	27	2	46	18
Alpine area	368	369	339	438
Continental area	33	5	58	19
<b>Total</b>	<b>401</b>	<b>374</b>	<b>397</b>	<b>457</b>

# Conclusion

The HPDA service was created for the needs of the ENVIRONMENTAL EXECUTIVE AGENCY (EIA), which is under the Ministry of the Environment and Water (MOEW) with the financial support of the ENTERPRISE FOR MANAGEMENT OF ENVIRONMENTAL PROTECTION ACTIVITIES (PUDOOS).

# Thank you!



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**EuroHPC**  
Joint Undertaking

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