Development and implementation of adaptation strategies to climate change in forest management

Razvoj i primena strategija prilagođavanja klimatskim promenama u gazdovanju šumama

ANKLIWA-DS

UNIQUE forestry and land use

Federal Office for Agriculture and Food

Republic of Serbia
Ministry of Agriculture, Forestry and Water Management

gef

Work package 2: (Further) Development of a modern digital site mapping, focusing on site vegetation analysis and tree species suitability analysis

Olivera Košanin FFUB

Janko Ljubičić FFUB

Albert Reif UF

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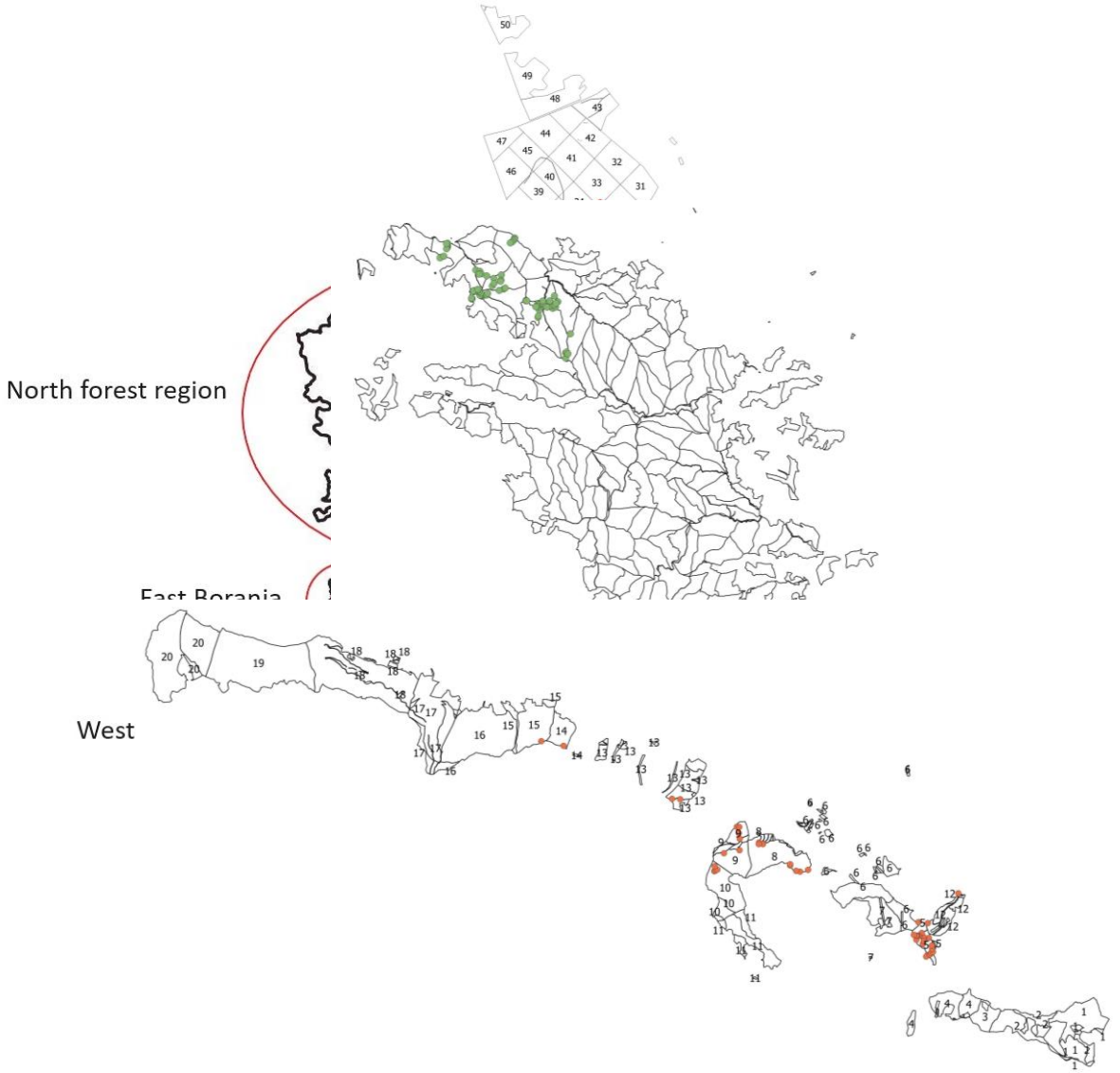
Work package 2: (Further) Development of a modern digital site mapping, focusing on site vegetation analysis and tree species suitability analysis

- Objectives of WP 2:
  - Improving the methodology for digital site mapping
  - Distribution of tree species and forest types in relation to temperature and requirements for water and nutrient regime (in the form of a bioclimatic complex)
  - Introduction of climate-sensitive models
  - Predicting future scenarios

Work package 2: (Further) Development of a modern digital site mapping, focusing on site vegetation analysis and tree species suitability analysis

- Study areas:
- MU „Visoka šuma-Lošinci“
- MU „Istočna Boranja“
- MU „Meliorativno zaštitne šume Rača“



Work tasks

- Phase I:
  - review of literature;
  - preparation of methodology;
  - field work (field reconnaissance, opening of soil profiles, soil sampling, vegetation relevés)
- Phase II:
  - sample processing (laboratory analysis of soil and analysis of vegetation relevés);
  - climate data preparation;
  - developing of methodology
- Phase III:
  - completing the methodology;
  - development of climate sensitive models

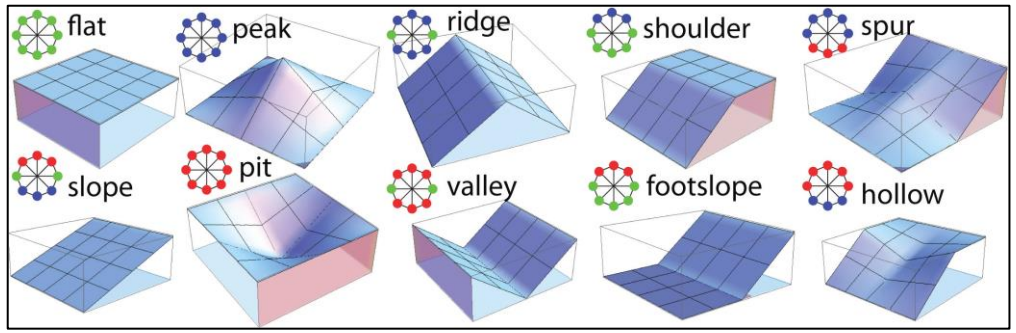
Phase I

- The focus is on
  2 species

- Parent material:
  - Srem- loessoid-marsh sediments (sand, siltstone sand, siltstone clay)
  - Istočna Boranja- limestone, phyllite and granodiorite
  - Tara- limestone

Phase I

- For beech, the soil profiles were placed at:
  - different forms of terrain - **geomorphones** (peak, ridge, shoulder, spur + slope, hollow, footslope and pit/valley)



  - different aspects:
    - warm (south, south-east, south-west and west);
    - neutral (all aspects up to 12.5°) and
    - cold (north, north-east, north-west and east)

  - and on slopes < 30° and > 30° (spur + slope and footslope)

Phase I

- A sufficient number of repetitions is required (3 pedological profiles per combination)

(geomorphon x aspect x slope) x parent material

- East Boranja- 100 soil profiles
- Tara- 44 soil profiles

Phase I

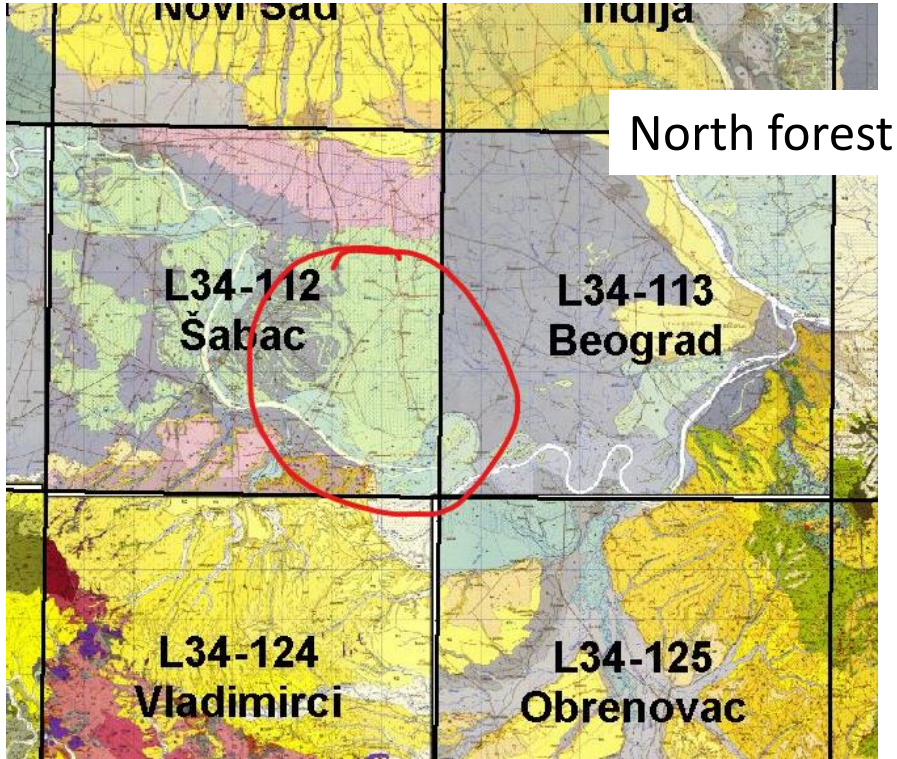
- For the pedunculate oak, the division by altitude was used
  - by analyzing the digital elevation model (DEM), it was divided into 6 classes

Class	Elevation (m)
1	72 – 74
2	75 – 76
3	77 – 78
4	79 – 80
5	81 – 84
6	85 – 89

- At the location of each soil profile, a Vegetation relevés (for vegetation analysis) was taken according to the Braun-Blanquet scale

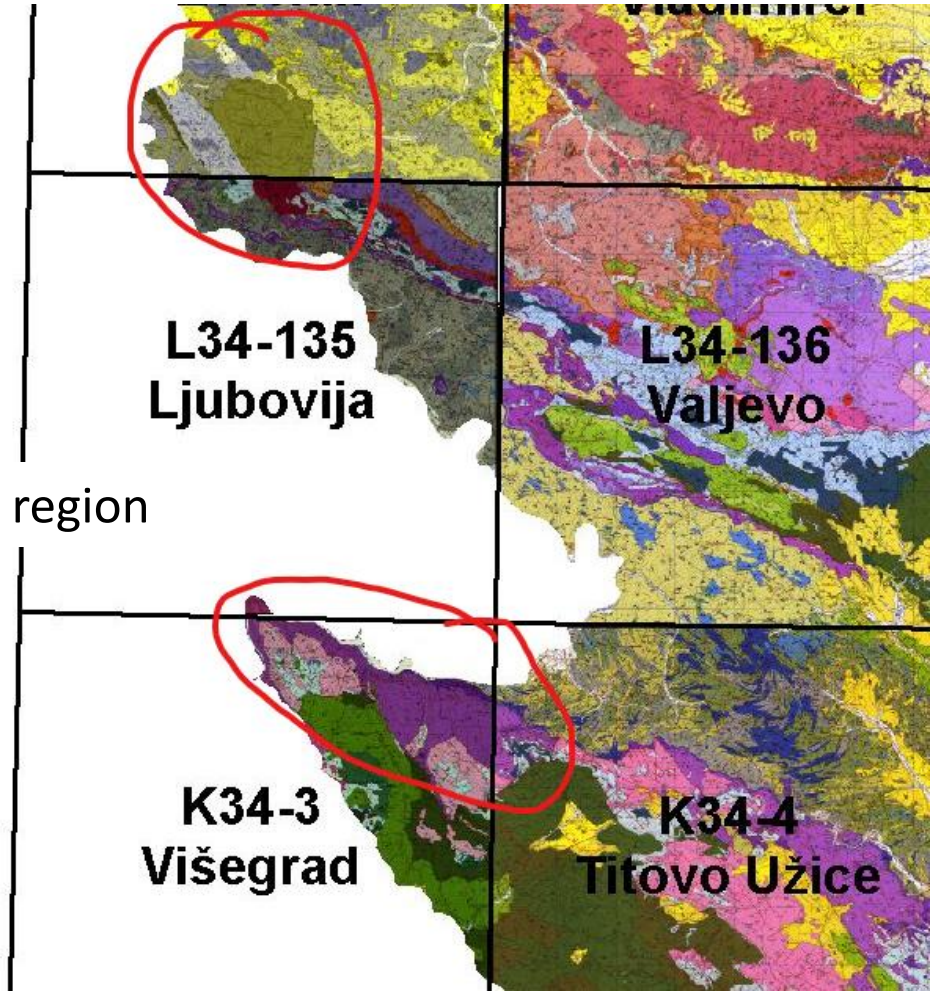
Phase I

- Parent material:
  - Pedunculate oak - alluvium
  - Beech - limestone, phyllite, granodiorite



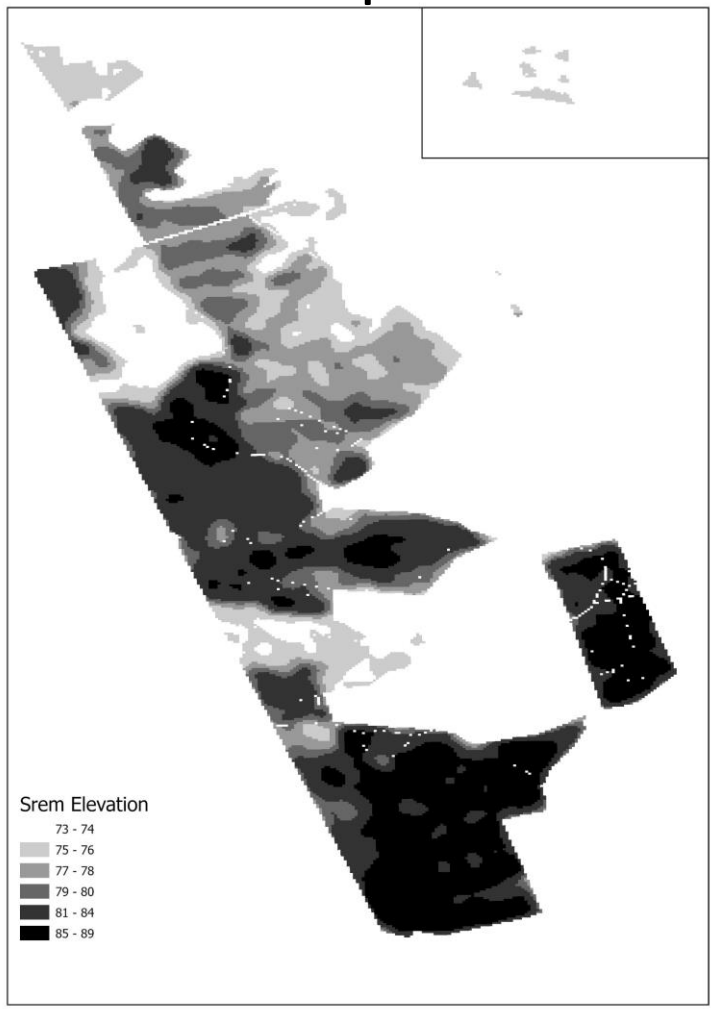
North forest region

West forest region



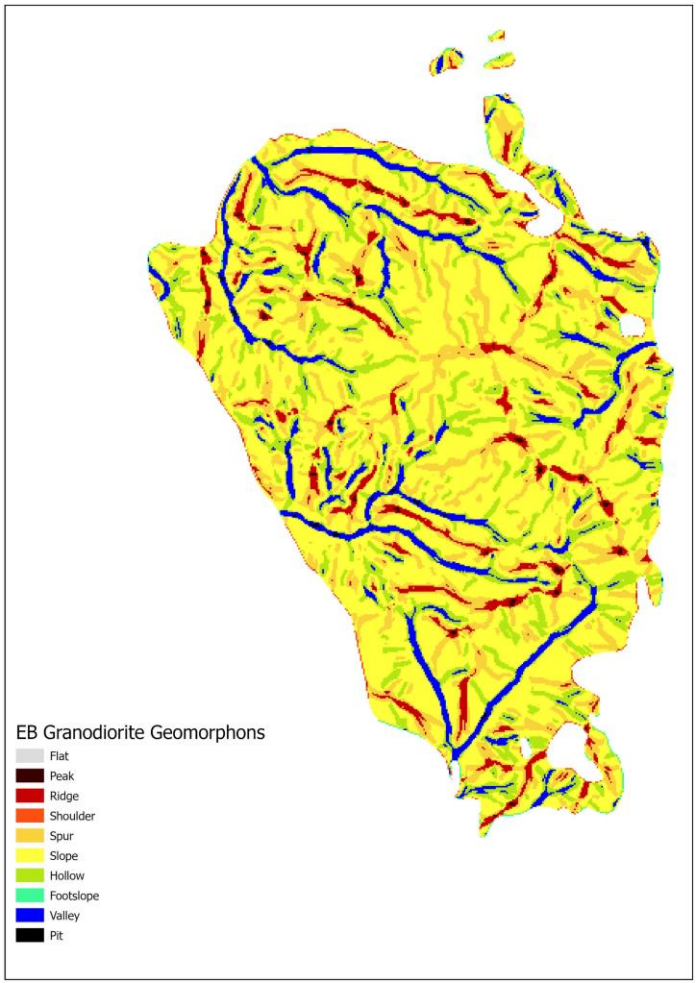
Phase I

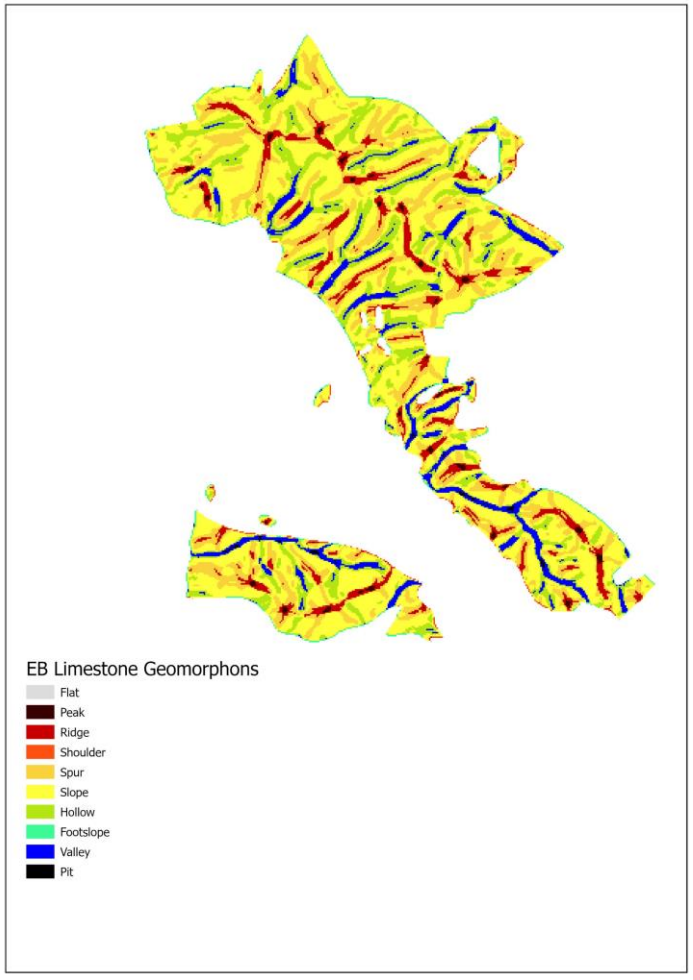
- Preparation of maps with elevations for pedunculate oak

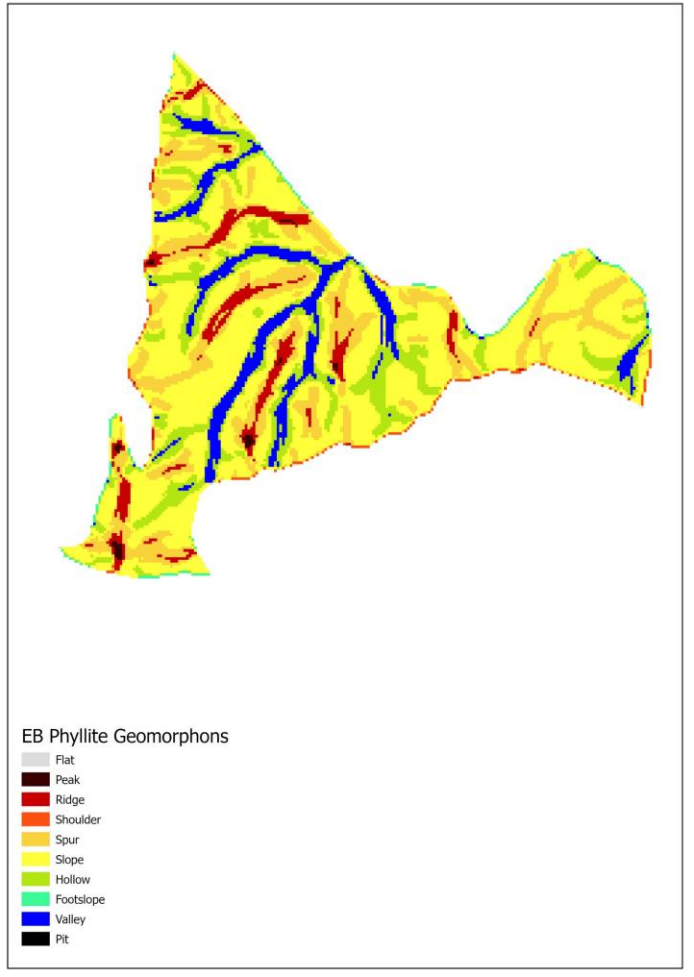


Phase I

- Preparation of maps with geomorphones for beech

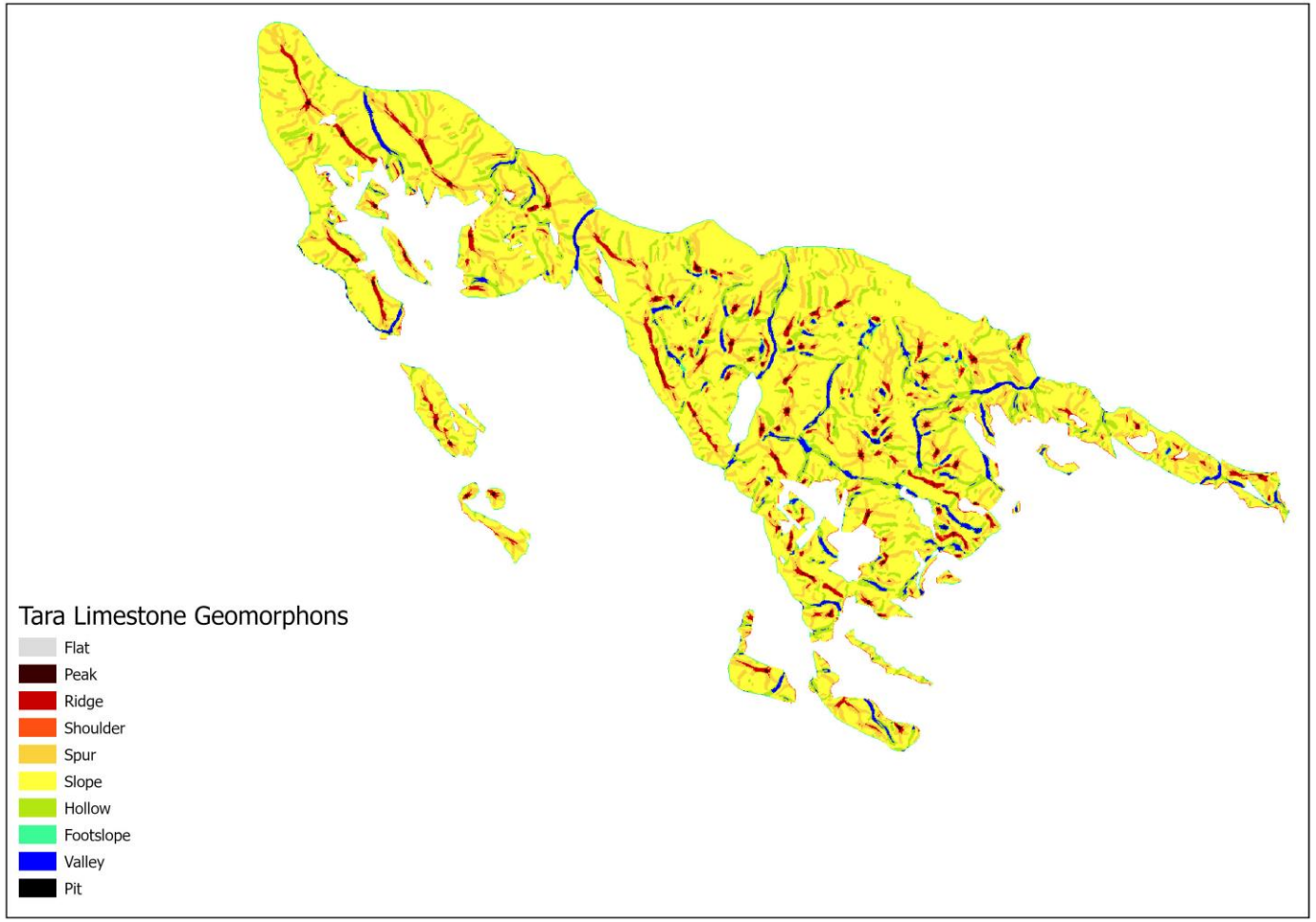




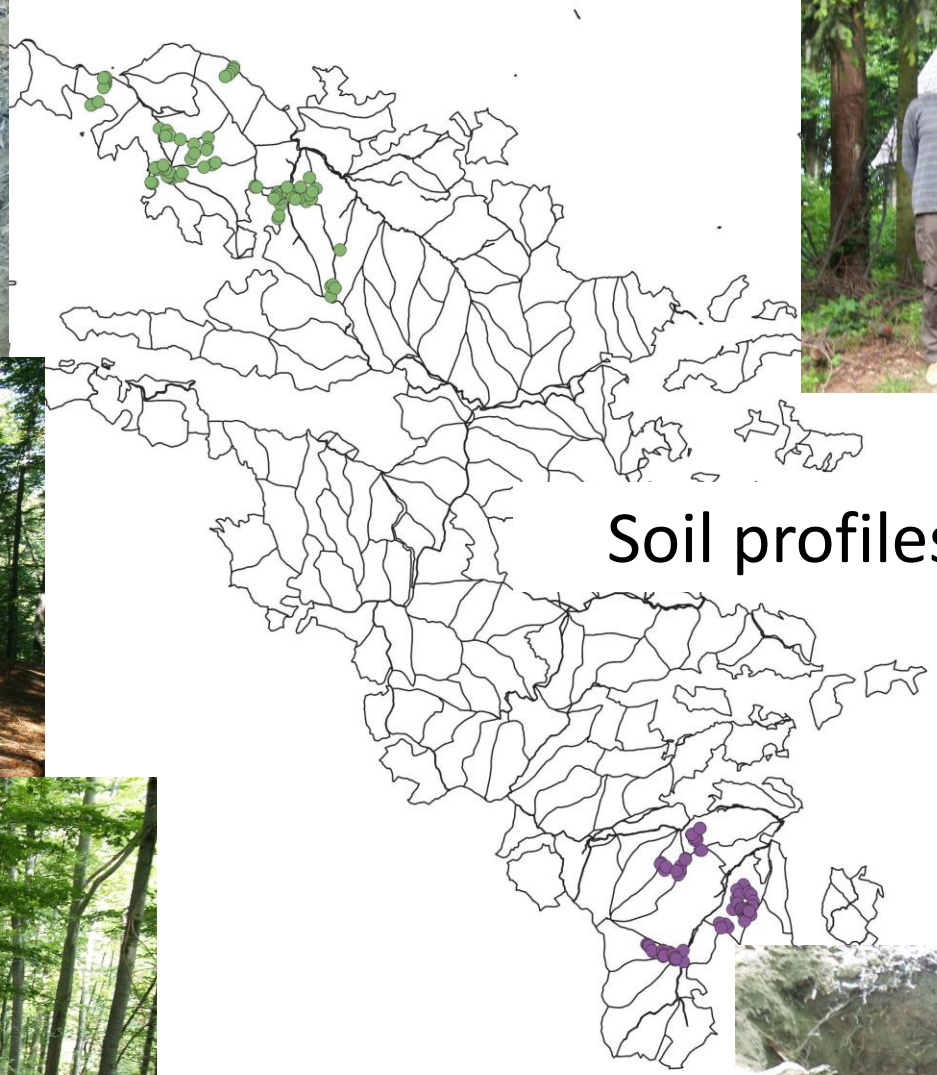


Phase I

- Preparation of maps with geomorphones for beech

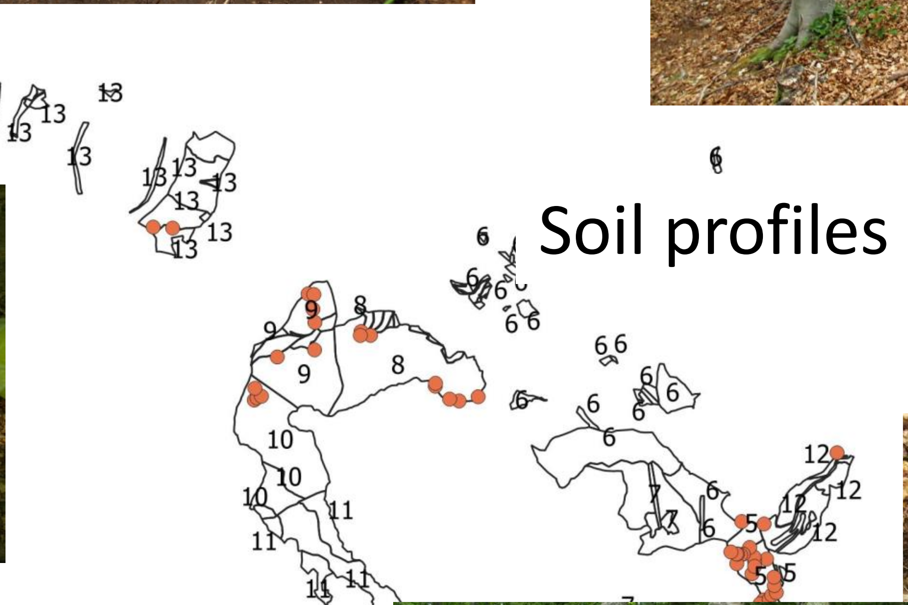


Soil profiles in Srem



Soil profiles on East Boranja

Soil profiles on Tara



Phase II

- Laboratory analysis of soil samples
  - analyzes of physical and chemical properties for site mapping and
  - for the purposes of the GOTILWA+ simulator

	Profile	Horizon	Depth (cm)	Coarse fraction (%)	Hygroscopic water (%)	Sand (2.0-0.06mm)	Silt (0.06-0.002mm)	Clay (< 0.002mm)	Texture class	AWChorizon (mm)	AWCprofile (mm)	Soil organic matter (L+F horizon) (g/0.0625cm^2)	Soil organic matter (L+F horizon) (g/m^2)
4	2/21	A	0-24		6.93	11.40	48.60	40.00	silty clay			93.58	1497.28
5		(B)rz	24-34		6.78	2.70	33.90	63.40	silty clay				
6	3/21	Ah	0-5	20	8.74	18.70	62.70	18.60	silt loam			133.83	2141.28
7		A	5-15	20	6.63	13.30	54.60	32.10	silty clay loam				
8		(B)rz	15-25	20	5.90	8.70	49.10	42.20	silty clay				
9	4/21	A	0-35	10	7.09	15.40	52.50	32.10	silty clay loam			90.20	1443.20
10	5/21	A	0-4		4.71	14.70	66.30	19.00	silt loam			64.87	1037.92
11		E or I	4-19		2.30	6.80	66.80	26.40	silt loam				
12		Bt or (B)	19-45		4.16	4.20	52.90	42.90	silty clay				
13	6/21	Ah	0-4	10	8.65	34.50	50.60	14.90	silt loam			115.6	1849.6
14		A	4-10	40	6.87	19.70	58.70	21.60	silt loam				
15		A or (B)	10-22	90	6.26	10.40	53.70	35.90	silty clay loam				
16	7/21	Ah	0-7	30	5.80	31.70	56.20	12.10	silt loam			87.94	1407.04
17		A	7-35	90	6.85	7.60	61.00	31.40	silty clay loam				
18	8/21	A	0-24	50	5.75	7.10	64.60	28.30	silty clay loam			77.50	1240.00
19	9/21	Olfh	2			0.00	0.00	0.00				90.03	1440.48
20		A	0-3		6.19	8.80	40.70	50.50	silty clay				
21		A or E	3-16	10	5.26	22.70	36.60	40.70	clay				
22		(B) or Bt	16-40	10	8.26	4.40	21.00	74.60	clay				
23	10/21	(B)rz	2-56	10	4.56	21.00	34.30	44.70	clay			124.24	1987.84
24	11/21	A	0-2		4.93	19.90	45.90	34.20	silty clay loam			149.50	2392.00
25			0-2		7.15	22.40	49.10	28.50	clay loam				
26			2-12		6.58	6.60	41.00	52.40	silty clay				

Chemical properties | Physical properties | Terrain

	Profile	Horizon	Depth						T (cmol/kg)	V (%)	CaCO3 (%)	Humus (%)	C (%)	N (%)	C/N	Available P2O5 (mg/100g)	Available K2O (mg/100g)
									99.33	91.82	–	31.78	18.43	1.64	11.24	5.72	19.59
									–	–	1.32	14.81	8.59	0.94	9.14	0.62	11.37
									61.14	63.79	–	17.44	10.12	0.88	11.50	1.80	11.83
									–	–	0.97	6.40	3.71	0.38	9.77	–	14.57
									60.03	81.05	–	26.42	15.32	1.32	11.61	3.49	24.16
									54.76	86.28	–	17.21	9.98	0.84	11.88	2.47	13.66
									–	–	0.83	8.77	5.09	0.47	10.82	0.27	11.83
									–	–	1.49	14.96	8.67	0.75	11.57	0.41	11.37
									62.49	38.89	–	18.86	10.94	0.96	11.39	5.01	15.94
									30.33	51.77	–	5.18	3.00	0.29	10.36	1.11	4.62
									34.17	86.32	–	4.28	2.48	0.27	9.19	–	8.18
									95.14	56.44	–	27.82	16.14	1.40	11.53	7.05	23.70
									58.30	75.38	–	17.17	9.96	0.91	10.95	3.79	14.11
									–	–	1.20	10.52	6.10	0.66	9.24	4.79	13.66
									–	–	–	36.12	20.95	1.64	12.77	5.28	23.70
									–	–	0.83	14.18	8.23	0.70	11.75	0.33	11.37
									50.30	92.25	–	11.33	6.57	0.56	11.73	0.46	7.72
19		[illegible]	[illegible]	[illegible]	[illegible]	–	–	–	–	–	–	49.10	28.48	1.37	20.79	–	–
20	9/21	A	0-3	6.18	5.44	24.25	15.76	33.90	49.66	68.26	–	6.81	3.95	0.32	12.34	3.13	11.83
21		A or E	3-16	5.52	4.69	42.00	27.30	20.10	47.40	42.41	–	5.40	3.13	0.23	13.62	1.15	7.72
22		(B) or Bt	16-40	7.34	6.34	6.25	4.06	40.30	44.36	90.84	–	2.18	1.26	0.13	9.72	0.10	17.77
23	10/21	(B)rz	2-56	7.48	6.20	5.00	3.25	30.10	33.35	90.25	–	1.62	0.94	–	–	0.18	18.68
24	11/21	A	0-2	5.86	5.21	28.75	18.69	30.40	49.09	61.93	–	12.82	7.43	0.80	9.29	5.47	18.22
27		A	0-5	5.53	4.95	35.00	22.75	23.40	46.15	50.70	–	9.97	5.78	0.46	12.57	3.56	16.18

Chemical properties | Physical properties | Terrain

Ready | Accessibility: Unavailable

- Soil texture
- Skeleton content
- pH value
- Content of organic matter (O_l and O_f)
- Field capacity
- Degree of soil saturation with bases
- ....

Phase II

- Vegetation relevés sorted into vegetation tables

	A	B
1	Profil	Tip šumske vegetacij
2	28	*Fagetum submontanum* subass.
3	29	*Fagetum submontanum*
4	30	*Asperulo odoratae-Fagetum*
5	31	*Luzulo-Fagetum*
6	32	*Pteridio-Fagetum*
7	33	*Fagetum submontanum*
8	34	*Festuco drymeiae-Fagetum*
9	35	*Fagetum submontanum*
10	36	*Luzulo-Fagetum*
11	37	*Fagetum submontanum* subass.
12	38	*Asperulo odoratae-Fagetum*
13	39	*Asperulo odoratae-Fagetum*
14	40	*Luzulo-Fagetum*
15	41	*Fagetum submontanum* subass.
16	42	*Musco-Fagetum*
17	43	*Vaccinio-Fagetum*
18	44	*Fagetum submontanum nudum*
19	45	*Fagetumsubmontanum*
20	46	*Fagetum submontanum*
21	47	*Musco-Fagetum*
22	48	*Vaccinio myrtilli-Fagetum*
23	49	*Luzulo-Fagetum*
24	50	*Luzulo-Fagetum*

Sheet1

	A	B
8	86	*Staphyleo-Fagetum* fac. *rubosum*
9	87	*Quercetum frainetto-cerridis* subass. *ornetosum*
10	88	*Quercetum frainetto-cerridis* subass. *ornetosum*
11	89	*Quercetum frainetto-cerridis* subass. *ornetosum*
12	90	*Quercetum frainetto-cerridis* subass. *ornetosum*
13	91	*Festuco drym*
14	92	*Fagetum subr*
15	93	*Fagetum subr*
16	94	*Ilici-Fagetum*
17	95	*Carpino betul*
18	96	*Carpino betul*
19	97	*Fraxino orni-*
20	98	*Ostryo-Faget*
21	99	*Fraxino orni-*
22	100	*Fagetum subr*
23	101	*Festuco drym*
24	102	*Fraxino orni-Quercetum petraeae*
25	103	*Tilio tomentosae-Quercetum petraeae*
26	104	*Tilio tomentosae-Fagetum* subass. *festucetosum drymeae*
27	105	*Querco-Fagetum*
28	106	*Festuco drymeiae-Fagetum*
29	107	*Fagetum submontanum subass. filicetosum*
30	108	*Asperulo odoratae-Fagetum*
31	109	*Fagetum submontanum subass. filicetosum*

Sheet1

Висока шума- Лошинци

1- Шума лужњака и обичног граба (*Querco-Carpinetum betuli*
2- Шума лужњака и беле тополе (*Populeto albae-Quercetum r*
3- Шума лужњака са бресовима (*Ulmeto-Quercetum roboris* M
4- Шума лужњака и пољског јасена (*Fraxino angustifoliae- Q*
& Tomić 1979)
5- Шума лужњака са усколисним шашем (*Quercetum roboris*
6- Шума лужњака са длакавом љубичицом (*Violo-Quercetum*
1980)

ика	1	2	3	4	5	6	
	дерске па	дерске па	дерске па	дерске па	дерске па	дерске па	
	3а	3а	3а	3а	3а	3а	
ина (m)	78-80	78-80	78-80	78-80	78-80	78-80	
	-	-	-	-	-	-	
	5	5	5	5	5	5	
	0.8	0.8	0.8	0.7	0.5	0.7	
(m)	11	18	17	12	10	12	
ик (cm)	20	30	30	30	20	30	
ње (m)	3	4	4	6	4	5	
	+	3.4	3.3	1.2	2.2	3.3	V
lvanica Marsch.	4.4	+			1.2	2.2	IV
a Ehr.		+	+	+			III
L.			+	+	1.1		III
	+		+				II
Moench			+	+			II
				+	1.1		II
				+	+		II
				2.2	+		II
olia (Ait.)Willd.		2.2	1.1				II
L.		1.1					I
na (Mill.)Swingle			+				I
a (Raf.)Schneid.			+				I
			+				I
	+						I
L.					+		I
Scop.		+					I
stanum L.				+			I
icus (L.)Koch				1.1			I
l.				1.1			I
				+			I
cacia L.			+				I
	0.1	0.7	0.3	0.5	0.8	0.6	
(m)	2	3	2	3	2	2	

Степен присутности

Phase II

- Analized climate data:
  - Average annual temperature (°C)
  - Average temperature of the growing season (°C)
  - Average temperature of the coldest month of the year (°C)
  - Extreme temperatures - min/max (°C)
  - Average annual rainfall (mm)
  - Average amount of precipitation in the growing season (mm)
  - Average amount of precipitation in summer (mm)
  - Potential evapotranspiration (mm^2/day)
  - Solar radiation (mj m^2/day)
  - Multi-year average wind speed (m/s)

Phase II

- To calculate the water balance level (WBL), the following is determined:
  - available water capacity (AWC) (by horizons and profile) - grouped into classes (7);
  - average total amount of precipitation in the summer months;
  - geomorphones and
  - total insolation

- The obtained values are inserted into the transformation table

Rrwarm			300 - 450			450 - 600			600-750			>750		
AWC [mm]	landscape unit	code	sun	mid	sha	sun	mid	sha	sun	mid	sha	sun	mid	sha
> 130	spur, slope; < 30 °	560	7	7	8	8	8	9	9	9	9	9	9	9
> 130	spur, slope; > 30 °	564	6	7	8	7	8	9	8	9	9	9	9	9
> 130	shoulder	400	6	6	7	7	7	8	8	9	9	9	9	9
> 130	peak	200	6	6	7	7	7	8	8	9	9	9	9	9
> 130	ridge	300	6	6	7	7	7	8	8	9	9	9	9	9
> 130	hollow; < 30 °	700	7	8	8	8	9	9	9	9	9	9	9	9
> 130	hollow; > 30 °	704	6	7	8	7	8	9	8	9	9	9	9	9
> 130	footslope	800	7	8	8	8	9	9	9	9	9	9	9	9
> 130	footslope; > 30 °	804	6	7	8	7	8	9	8	9	9	9	9	9
> 130	valley, pit	900	8	8	9	9	9	9	9	9	9	9	9	9
95 - 130	spur, slope; < 30 °	560	6	6	7	7	7	8	8	8	8	9	9	9
95 - 130	spur, slope; > 30 °	564	5	6	7	6	7	8	7	8	8	8	9	9
95 - 130	shoulder	400	5	5	6	6	6	7	7	8	8	8	9	9
95 - 130	peak	200	5	5	6	6	6	7	7	8	8	8	9	9
95 - 130	ridge	300	5	5	6	6	6	7	7	8	8	8	9	9
95 - 130	hollow; < 30 °	700	6	7	7	7	8	8	8	8	8	9	9	9
95 - 130	hollow; > 30 °	704	5	6	7	6	7	8	7	8	8	8	9	9
95 - 130	footslope	800	6	7	7	7	8	8	8	8	9	9	9	9

Phase II

- Table of frequencies for water balance (WBL)

RrWarm	geomorfon	300-450mm									Sum	Tl sun						Ti mid				Ti sha				
		1	2	3	4	5	6	7	8	9		3	4	5	6	7	8	5	6	7	8	5	6	7	8	9
više od 130mm	200						3				3								3							
	300						4	1			5								3				1	1		
	400					1	9	4			14				4			1	5					4		
	560							10	8		18					5				5					8	
	564							2			2													2		
	700								4		4														4	
	704			1	1						2	1	1													
	800							8			8					7								1		
	804					1			3		4											1			3	
	900								1		1						1									

- Transfer table

Geom	Ti sun	Ti mid	Ti sha
200	5	6	6
300	5	6	6
400	6	6	7
560	7	7	8
564	5	6	7
700	7	7	8
740	4	5	6
800	7	7	8
804	7	7	7
900	8	8	9

WBL	Class	Water deficit
1	Extremely dry	Very long periods of water deficit
2	Very dry	Long periods of water deficit
3	Dry	Longer periods of water deficit
4	Medium dry	Occasionally in longer periods of water deficit
5	A little wet	In shorter periods of water deficit
6	Moderately humid	Occasionally in short periods of water deficit
7	Wet	Rarely water deficit
8	Very humid	Water deficiency is very rare
9	Extremely humid	Extremely rare water deficiency

Phase II

- Determination of nutrient regime (NR)
- The most common parameter to determine is the base saturation (BS) or pH in H_2O
- A classification scheme is used

coarse fraktion	< 50 %	> 50 %		
		alkanality of bedrock		
pH class		high	medium	less
1	rich	rich	rich-medium	rich-medium
2	rich-medium	rich-medium	rich-medium	medium
3	medium	rich-medium	medium	medium
4	medium	medium	medium	medium-poor
5	medium-poor	medium	medium-poor	medium-poor
6	poor	medium-poor	medium-poor	poor

GEOM	rich	ch-mediu	medium	edium-po	poor	Total
200					1	1
300					4	4
400				1	4	5
560					9	9
564				3	12	15
700						0
800	1		1	2	1	5
804				2	1	3
900				2	2	4
Suma	0	0	1	10	34	46

Phase III

- In GIS software the following are connected:

geomorphon and elevation maps prepared

data from transfer tables for water balance and nutritional regime

site maps

Phase III


Srem, WBL and NR
Extremely humid, Rich-medium
Very humid, Rich
Very humid, Rich-medium

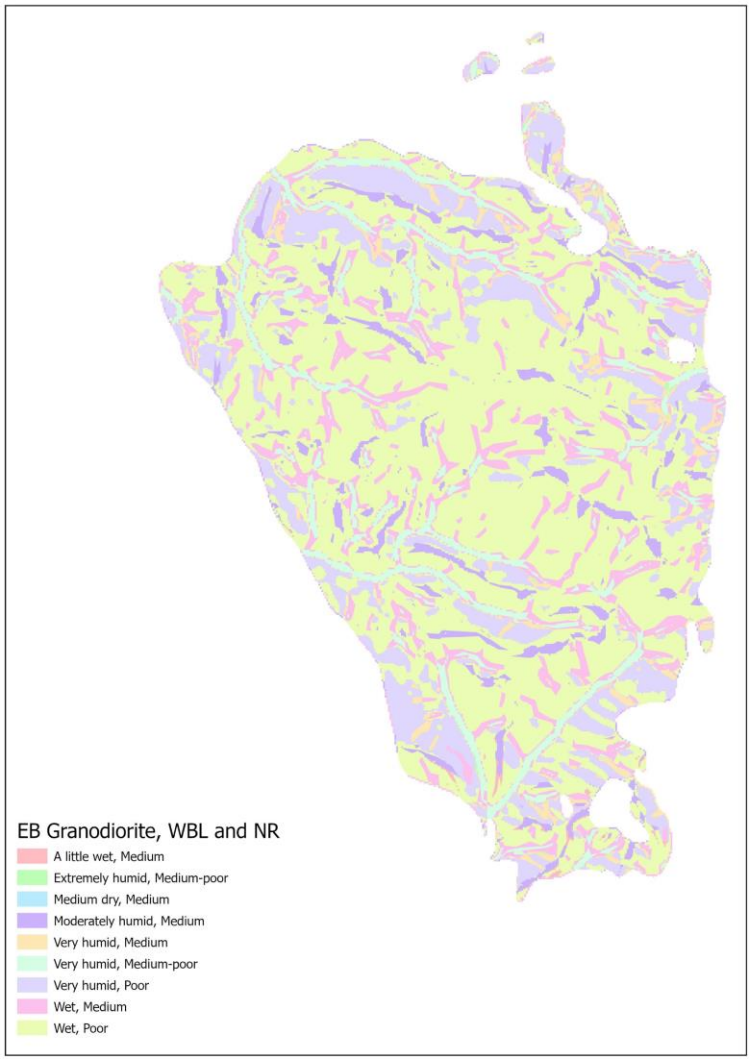
Phase III

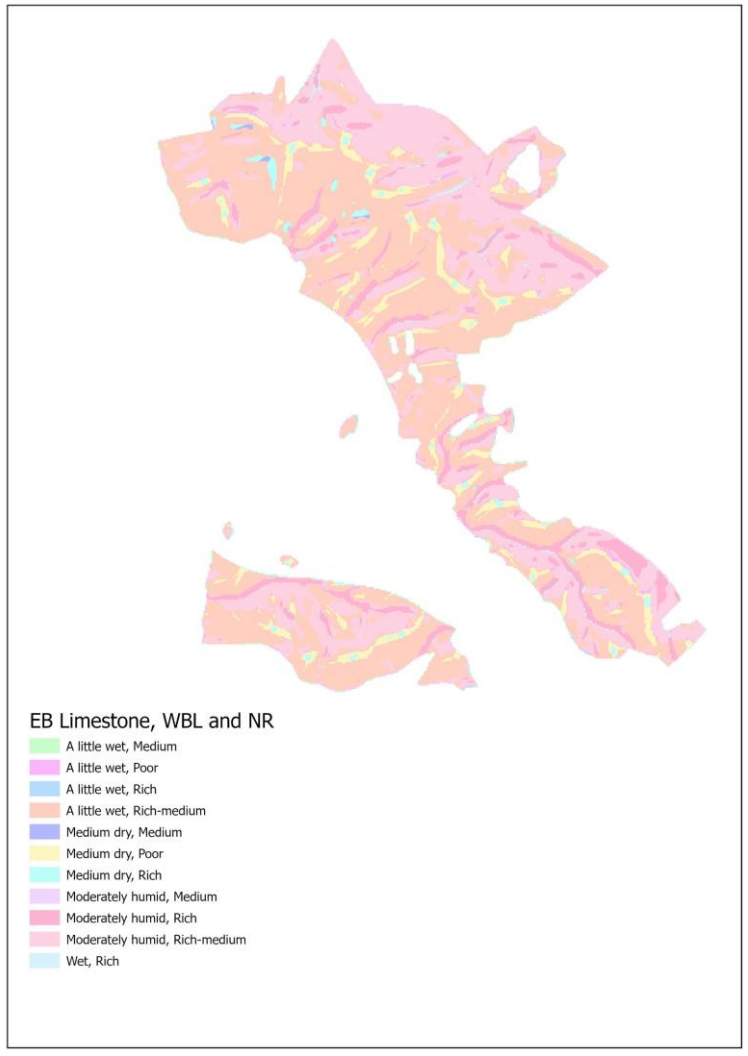
- Pedunculate oak in MU „Visoka šuma-Lošinci“
- Alluvium:
  - 6 site types are defined

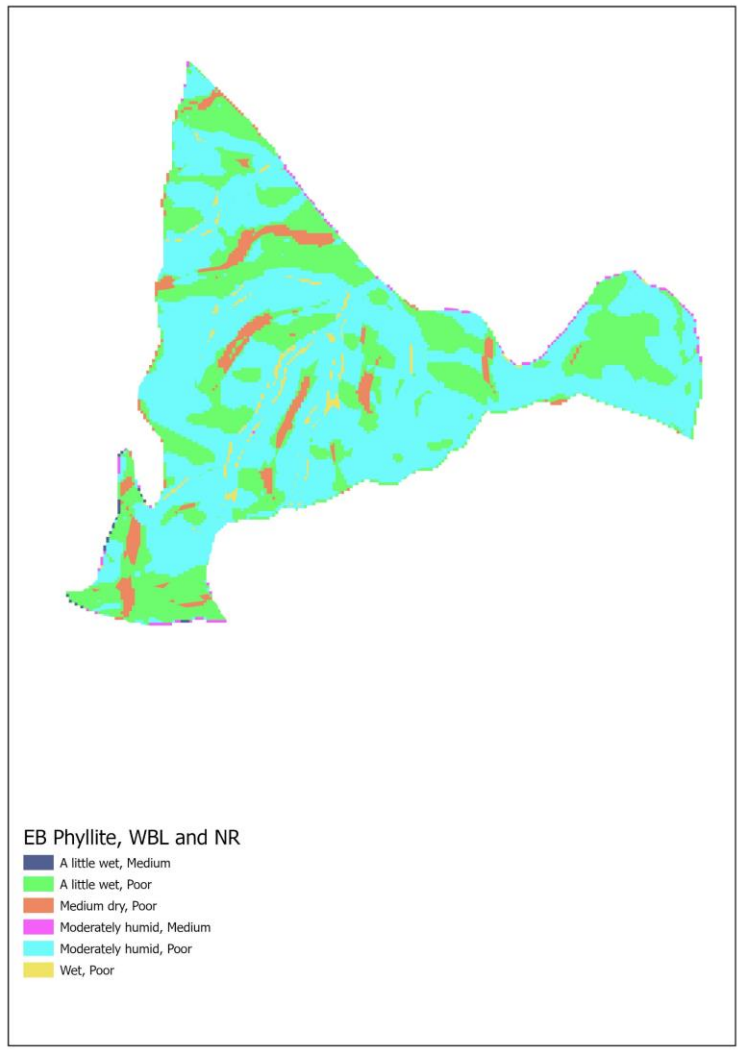
WBL	Water balance level (class)	Water deficit	Nutrient regime	Area (ha)	%
9	Extremely humid	Extremely rare water deficiency	Rich-medium	228.82	10.92%
8	Very humid	Water deficiency is very rare	Rich	285.01	13.61%
8	Very humid	Water deficiency is very rare	Rich-medium	1580.74	75.47%

9	Extremely humid	Extremely rare water deficiency	Rich-medium	228.82	10.92%
8	Very humid	Water deficiency is very rare	Rich	285.01	13.61%
8	Very humid	Water deficiency is very rare	Rich	1580.74	75.47%

Phase III


EB Granodiorite, WBL and NR
A little wet, Medium
Extremely humid, Medium-poor
Medium dry, Medium
Moderately humid, Medium
Very humid, Medium
Very humid, Medium-poor
Very humid, Poor
Wet, Medium
Wet, Poor


EB Limestone, WBL and NR
A little wet, Medium
A little wet, Poor
A little wet, Rich
A little wet, Rich-medium
Medium dry, Medium
Medium dry, Poor
Medium dry, Rich
Moderately humid, Medium
Moderately humid, Rich
Moderately humid, Rich-medium
Wet, Rich


EB Phyllite, WBL and NR
A little wet, Medium
A little wet, Poor
Medium dry, Poor
Moderately humid, Medium
Moderately humid, Poor
Wet, Poor

Phase III

- Beech in MU „East Boranja“
- Granodiorite:
  - 9 site types are defined

WBL	Water balance level (class)	Water deficit	Nutrient regime	Area (ha)	%
4	Medium dry	Occasionally in longer periods of water deficit	Medium	0.14	0.00%
5	A little wet	In shorter periods of water deficit	Medium	16.47	0.24%
6	Moderately humid	Occasionally in short periods of water deficit	Medium	378.83	5.58%
7	Wet	Rarely water deficit	Medium	890.39	13.12%
7	Wet	Rarely water deficit	Poor	3788.65	55.81%
8	Very humid	Water deficiency is very rare	Medium	184.46	2.72%
8	Very humid	Water deficiency is very rare	Medium-poor	440.91	6.49%
8	Very humid	Water deficiency is very rare	Poor	1080.06	15.91%
9	Extremely humid	Extremely rare water deficiency	Medium-poor	8.98	0.13%

7	Wet	Rarely water deficit	Medium	890.39	13.12%
8	Very humid	Water deficiency is very rare	Poor	1080.06	15.91%
7	Wet	Rarely water deficit	Poor	3788.65	55.81%

Phase III

- Beech in MU „East Boranja“
- Limestone:
  - 11 site types are defined

WBL	Water balance level (class)	Water deficit	Nutrient regime	Area (ha)	%
4	Medium dry	Occasionally in longer periods of water deficit	Medium	3.82	0.11%
4	Medium dry	Occasionally in longer periods of water deficit	Rich	60.61	1.79%
4	Medium dry	Occasionally in longer periods of water deficit	Poor	221.82	6.56%
5	A little wet	In shorter periods of water deficit	Rich	4.28	0.13%
5	A little wet	In shorter periods of water deficit	Medium	11.78	0.35%
5	A little wet	In shorter periods of water deficit	Poor	17.95	0.53%
5	A little wet	In shorter periods of water deficit	Rich-medium	1678.51	49.63%
6	Moderately humid	Occasionally in short periods of water deficit	Medium	38.37	1.13%
6	Moderately humid	Occasionally in short periods of water deficit	Rich	269.57	7.97%
6	Moderately humid	Occasionally in short periods of water deficit	Rich-medium	1055.16	31.20%
7	Wet	Rarely water deficit	Rich	20.52	0.61%

4	Medium dry	Occasionally in longer periods of water deficit	Poor	221.82	6.56%
6	Moderately humid	Occasionally in short periods of water deficit	Rich	269.57	7.97%
6	Moderately humid	Occasionally in short periods of water deficit	Rich-medium	1055.16	31.20%
5	A little wet	In shorter periods of water deficit	Rich-medium	1678.51	49.63%

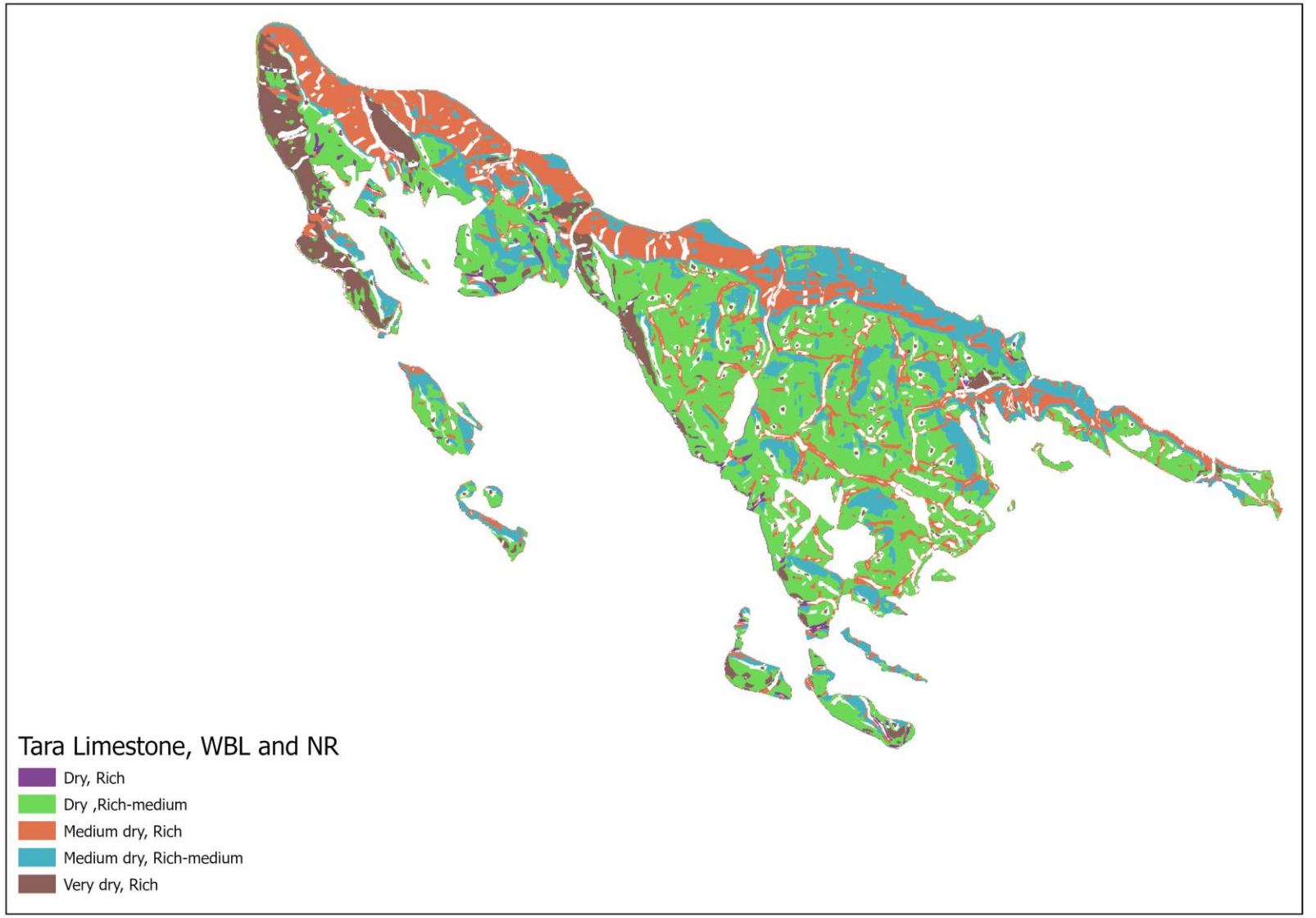
Phase III

- Beech in MU „East Boranja“
- Phyllite:
  - 6 site types are defined

WBL	Water balance level (class)	Water deficit	Nutrient regime	Area (ha)	%
5	A little wet	In shorter periods of water deficit	Medium	1.6	0.15%
6	Moderately humid	Occasionally in short periods of water deficit	Medium	7.97	0.76%
7	Wet	Rarely water deficit	Poor	15.7	1.51%
4	Medium dry	Occasionally in longer periods of water deficit	Poor	54.03	5.18%
5	A little wet	In shorter periods of water deficit	Poor	344.67	33.05%
6	Moderately humid	Occasionally in short periods of water deficit	Poor	618.88	59.35%

4	Medium dry	Occasionally in longer periods of water deficit	Poor	54.03	5.18%
5	A little wet	In shorter periods of water deficit	Poor	344.67	33.05%
6	Moderately humid	Occasionally in short periods of water deficit	Poor	618.88	59.35%

Phase III


Tara Limestone, WBL and NR
Dry, Rich
Dry ,Rich-medium
Medium dry, Rich
Medium dry, Rich-medium
Very dry, Rich

Phase III

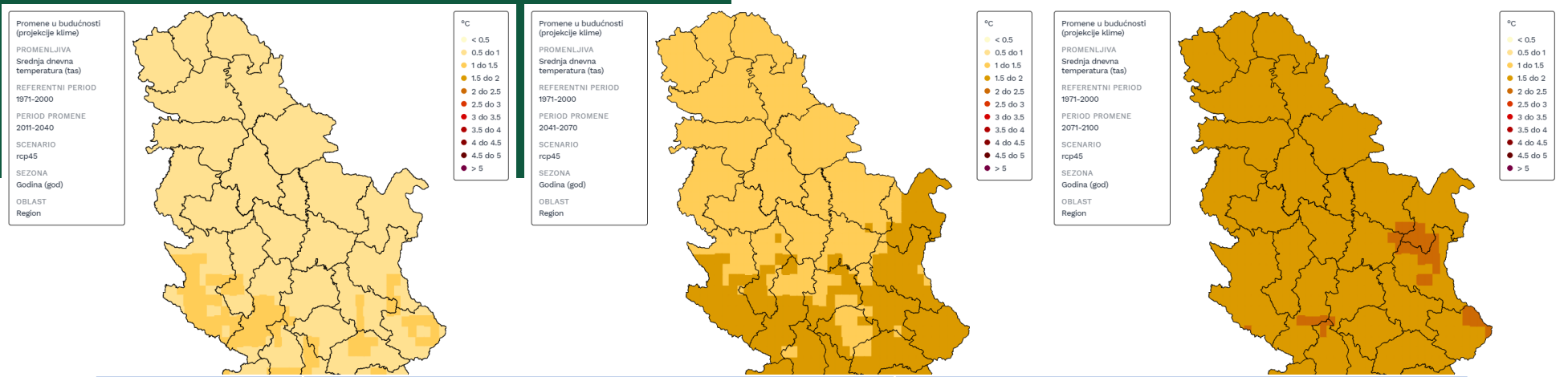
- Beech in MU „Meliorativno zaštitne šume Rača“
- Limestone:
  - 5 site types are defined

WBL	Water balance level (class)	Water deficit	Nutrient regime	Area (ha)	%
3	Dry	Longer periods of water deficit	Rich	284.01	2.03%
2	Very dry	Long periods of water deficit	Rich	1184.6	8.47%
4	Medium dry	Occasionally in longer periods of water deficit	Rich-medium	2862.66	20.46%
4	Medium dry	Occasionally in longer periods of water deficit	Rich	3261.24	23.30%
3	Dry	Longer periods of water deficit	Rich-medium	6401.26	45.74%

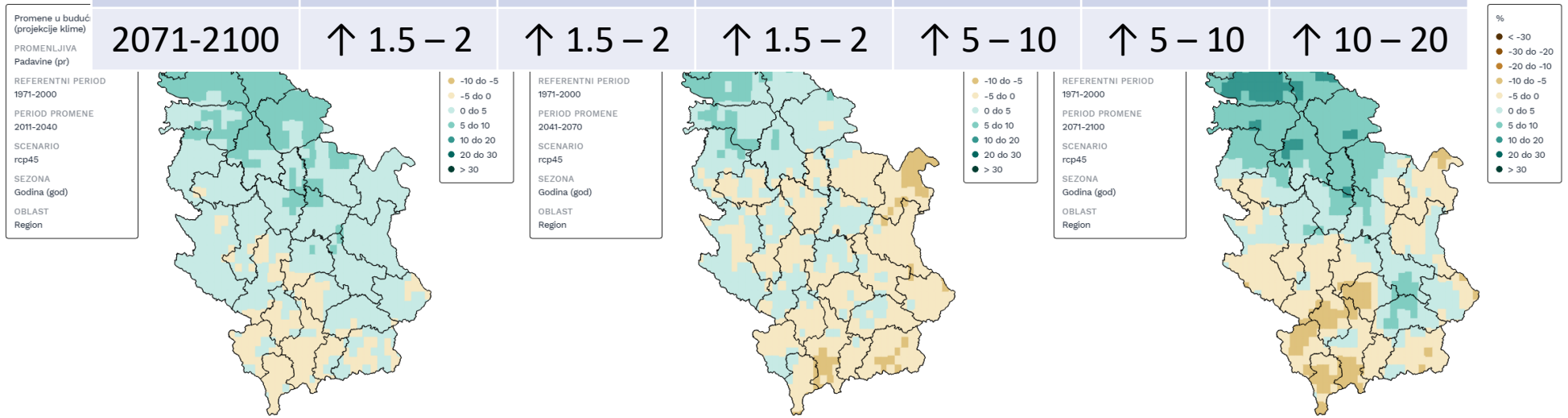
4	Medium dry	Occasionally in longer periods of water deficit	Rich-medium	2862.66	20.46%
4	Medium dry	Occasionally in longer periods of water deficit	Rich	3261.24	23.30%
3	Dry	Longer periods of water deficit	Rich-medium	6401.26	45.74%

Phase III

https://atlas-klime.eko.gov.rs



Period	T (°C)			P (%)		
	EB	Tara	Srem	EB	Tara	Srem
2011-2040	↑ 0.5 – 1	↑ 0.5 – 1	↑ 0.5 – 1	↑ 0 – 5	↑ 0 – 5	↑ 0 – 5
2041-2070	↑ 1 – 1.5	↑ 1 – 1.5	↑ 1 – 1.5	↑ 0 – 5	↓ 0 – -5	↑ 5 – 10
2071-2100	↑ 1.5 – 2	↑ 1.5 – 2	↑ 1.5 – 2	↑ 5 – 10	↑ 5 – 10	↑ 10 – 20



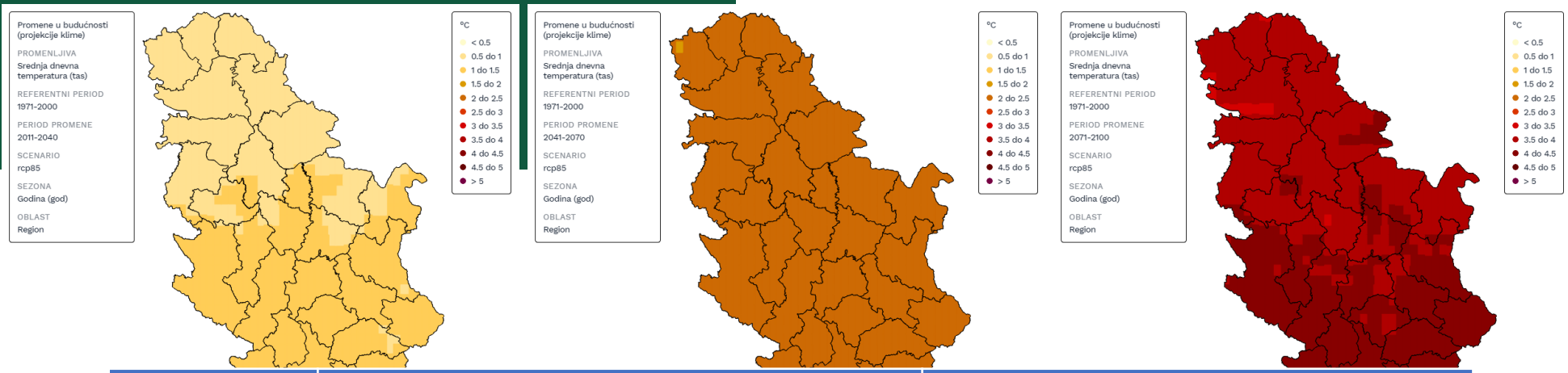
Climate changes according to the RCP 4.5 scenario (with mitigation)

Reference period

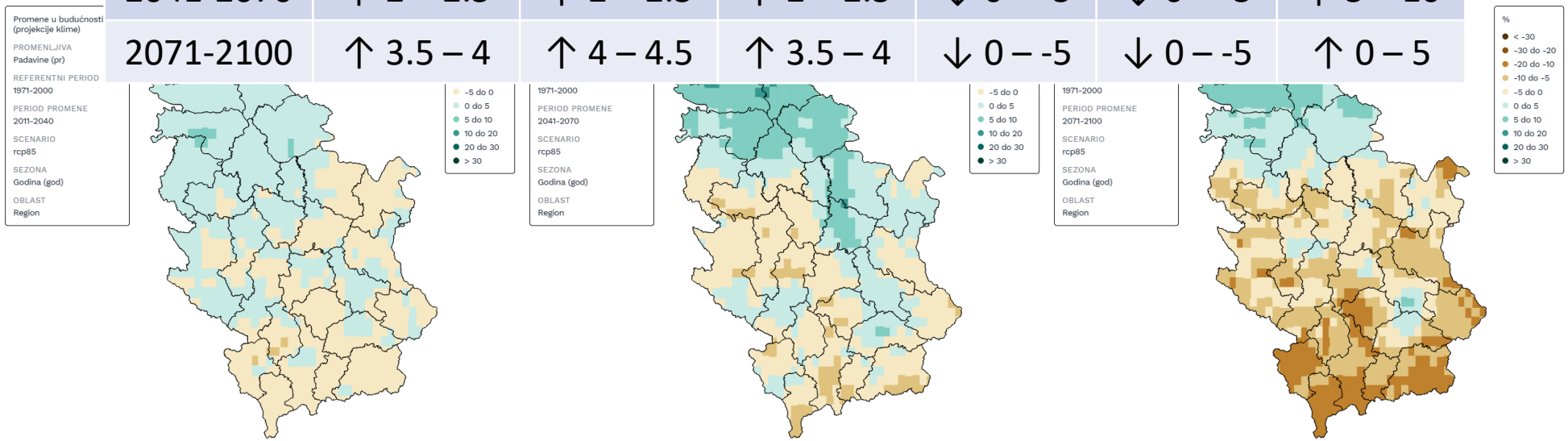
1971-2000

Фаза III

https://atlas-klime.eko.gov.rs



Period	T (°C)			P (%)		
	EB	Tara	Srem	EB	Tara	Srem
2011-2040	↑ 0.5 – 1	↑ 1 – 1.5	↑ 0.5 – 1	↑ 0 – 5	↑ 0 – 5	↑ 0 – 5
2041-2070	↑ 2 – 2.5	↑ 2 – 2.5	↑ 2 – 2.5	↓ 0 – -5	↓ 0 – -5	↑ 5 – 10
2071-2100	↑ 3.5 – 4	↑ 4 – 4.5	↑ 3.5 – 4	↓ 0 – -5	↓ 0 – -5	↑ 0 – 5



Climate changes according to the RCP 8.5 scenario (without mitigation)

Reference period

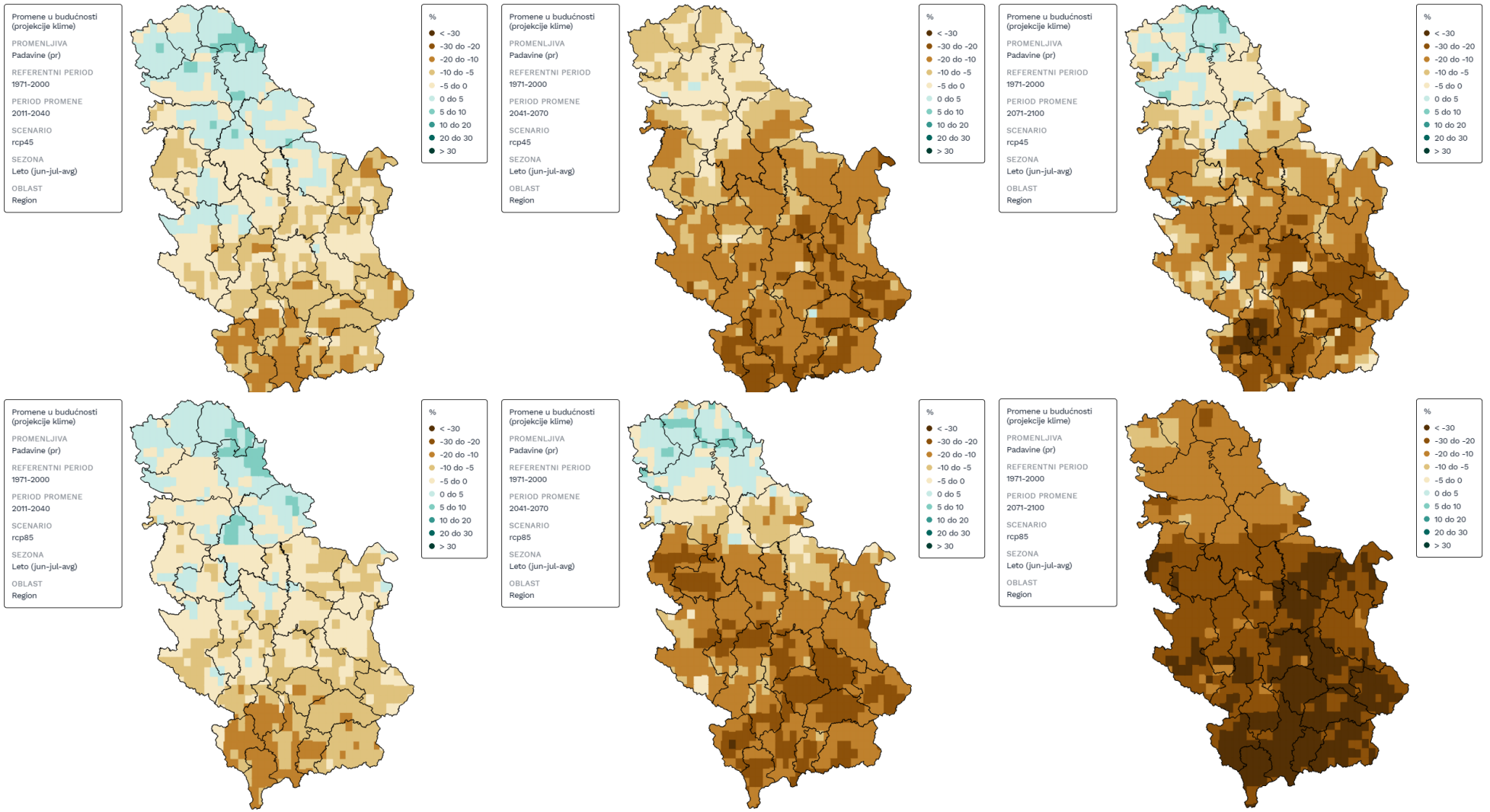
1971-2000

Фаза III

- Precipitation in summer months are important for site mapping

- RCP 4.5
- ↓ 5-10% oak
- ↓ 10-20% beech

- RCP 8.5
- ↓ 20-30% oak
- ↓ 5->30% beech



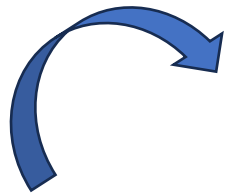
Phase III

- A decrease of up to 30% results in a decrease in precipitation in the growing season, the amount of precipitation falls below 300 mm and as a result there is a change in the water balance

Water balance classes

decrease by one

geom	TiS	Tin	Tih
200	4	4	5
300	4	4	5
400	4	4	5
560	5	5	6
564	4	5	6
700	5	6	6
740	4	5	6
800	5	6	6
804	4	5	6
900	6	6	7



geom	TiS	Tin	Tih
200	3	3	4
300	3	3	4
400	3	3	4
560	4	4	4
564	3	4	5
700	4	5	5
740	3	4	5
800	4	5	5
804	4	4	5
900	5	5	6

Фаза III

- Srem

Current class	Future class
9- Extremely humid	8- Very humid
8- Very humid	7- Wet

- Istočna Boranja

Current class	Future class
8- Very humid	7- Wet
7- Wet	6- Moderately humid
6- Moderately humid	5- A little wet
5- A little wet	4- Medium dry
4- Medium dry	3- Dry

- Tara

Current class	Future class
4- Medium dry	3- Dry
3- Dry	2- Very dry

Phase III

- Vegetation analyzes
- In Srem, there are 6 vegetation relevés in which the pedunculate oak is dominant:
  - *Populeto albae-Quercetum roboris* B. Jov.
  - *Violo-Quercetum roboris* B. Jovanović & Tomić 1980
  - *Fraxino angustifoliae-Quercetum roboris* B. Jovanović & Tomić 1979
  - *Quercetum roboris subass. caricetosum brizoides*
  - *Ulmeto-Quercetum roboris* Mišić & Čolić 1974.
  - *Carpino betuli-Quercetum roboris* Anić 1959.

- The studied communities represent drier varieties, in which the pedunculate oak is mostly dominant, but due to changes in climate and habitat conditions (underground water), other species will find their optimum for growth and development:

Carpinus betulus, Ulumus effusa, Ulmus campestris

Phase III

- Vegetation analyzes
- In MU „East Boranja“:
  - on granodiorite are 4 communities- beech is dominant
  - on limestone are 10 communities – beech is dominant, but there is also *Q. cerris*, *Q. frainetto*, *C. betulus*, *A. campestre*
  - on phyllite are 7 communities- beech is dominant, *C. betulus* occurs

- In the studied communities, beech dominates, and after the climate change, other species will find optimum for growth and development in addition to beech:

Quercus cerris, Quercus frainetto, Carpinus betulus

Phase III

- Vegetation analyzes
- In MU „Meliorativno zaštitne šume Rača“
  - on limestone are 10 communities- beech is dominant

- In the studied communities, beech dominates, and due to climate changes, besides beech, other species will find their optimum for growth and development:

Quercus cerris, Ostrya carpinifolia

Development and implementation of adaptation strategies to climate change in forest management

Razvoj i primena strategija prilagođavanja klimatskim promenama u gazdovanju šumama

ANKLIWA-DS

UNIQUE forestry and land use

Federal Office for Agriculture and Food

Republic of Serbia
Ministry of Agriculture, Forestry and Water Management

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Olivera Košanin FFUB

Janko Ljubičić FFUB

Albert Reif UF

Thank you for your attention