

Seasonal movement patterns and space use of golden jackal (*Canis aureus*) in the suburban areas of Serbia

Ilija Pantelić, Neda Bogdanović and Duško Ćirović

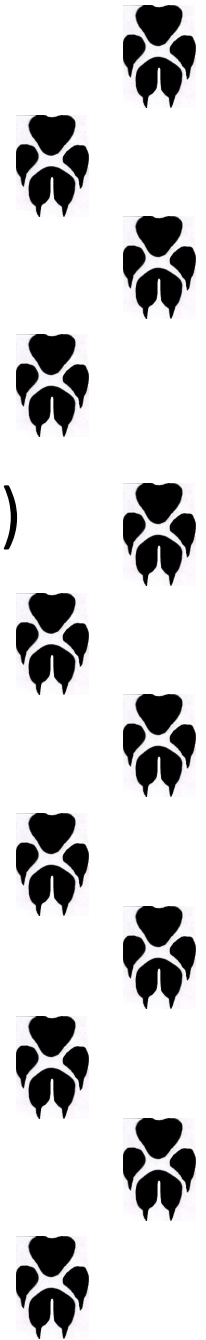
MATE



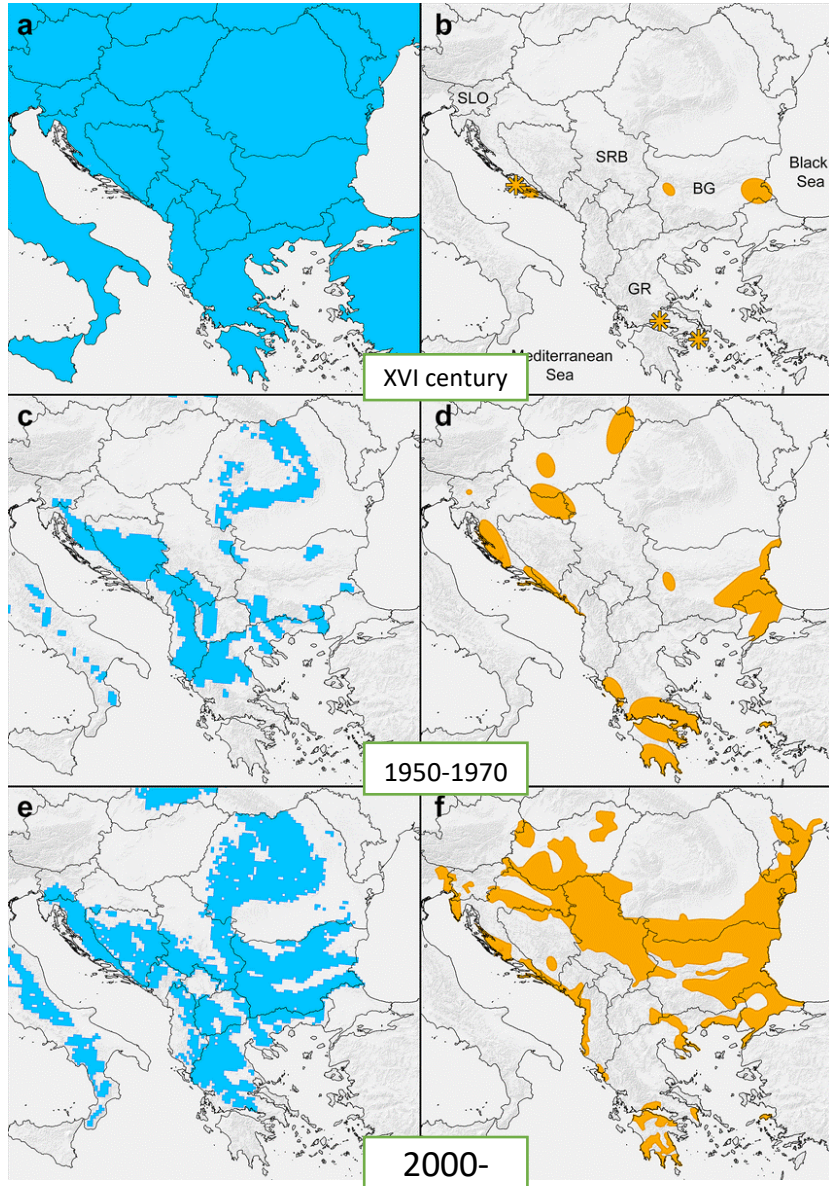
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SYMPOSIUM
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GÖDÖLLŐ, HUNGARY



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Distribution and expansion



- 🐾 Present in the Balkan since the neolite
- 🐾 An omnivorous mesocarnivore
- 🐾 An expanding species in Europe due to:
 - 🐾 Lack of Top-down suppression by apex predator
 - 🐾 Modifications of habitat
 - 🐾 Climate change
 - 🐾 New sources of food
 - 🐾 Causes sporadic damages to livestock and is a zoonosis source but also a regulator of rodent populations





Distribution of *Canis aureus*
per Johnatan Hornburg, based on IUCN Red list data




Distribution



 Present on the whole territory.

 Largest densities is near the Danube:
Negotin valley, Morava valley, Danube valley and Srem

Genetics

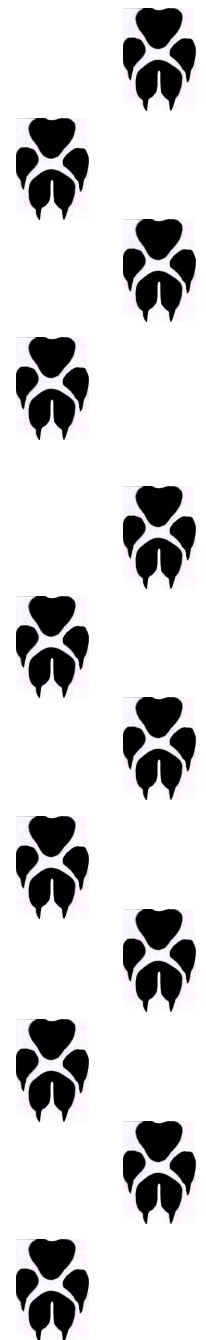
 Serbian jackals have no mtDNA variability and low nuclear DNA variability (average observed and expected heterozygosity of 0.29 and 0.34, respectively) which suggests a strong founder effect (Zachos et al. 2009)

In Serbia

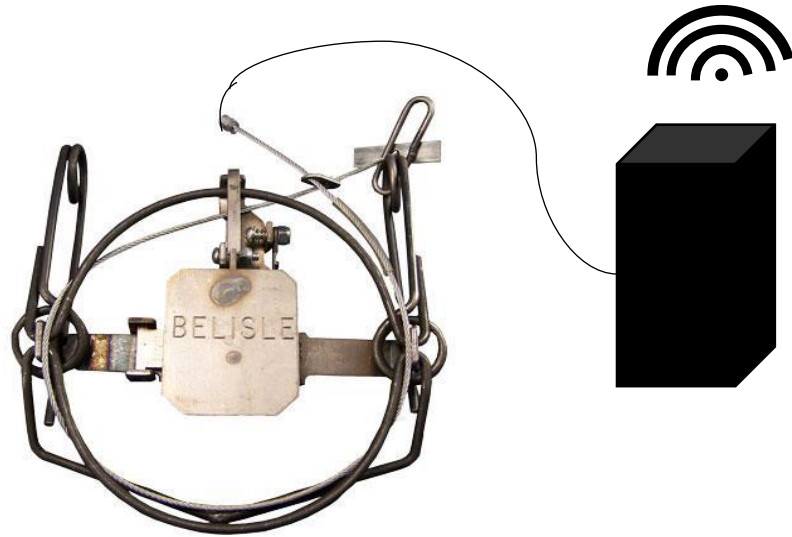
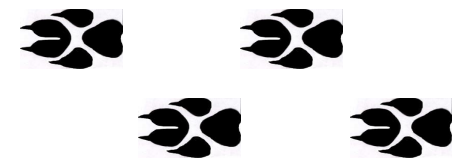
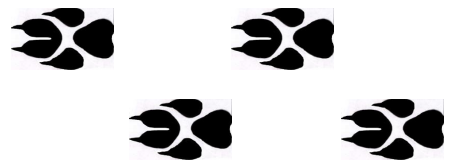
Diet

Food category	Surčin N=93	
	%O	%B
Domestic ungulates	23.20	37.18
Poultry	5.52	7.09
Small mammals	27.62	27.07
Wild boar	7.18	6.91
Roe deer	2.21	5.92
Hare	3.31	3.14
Game birds	0.00	0.00
Other birds	4.97	0.78
Plant material	13.26	2.58
Other carnivores	1.10	6.78
Cats and dogs	1.66	1.47
Reptiles and amphibians	1.10	0.09
Indigestible	4.42	0.48
Invertebrates	3.87	0.48
Fish	0.55	0.03

N represents the number of stomach samples.



Methodology



I

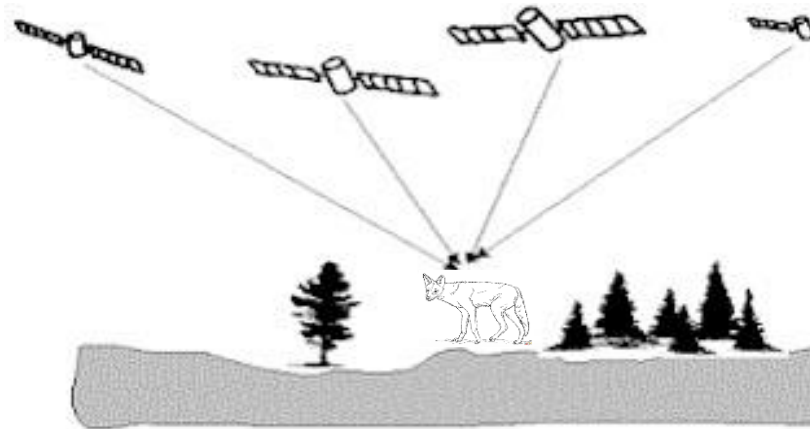
Capture via Belisle 6" and carcass/scent bait



foto: D. Ćirović

II

Mesuring, collaring and release



III

GPS tracking every 3h



IV

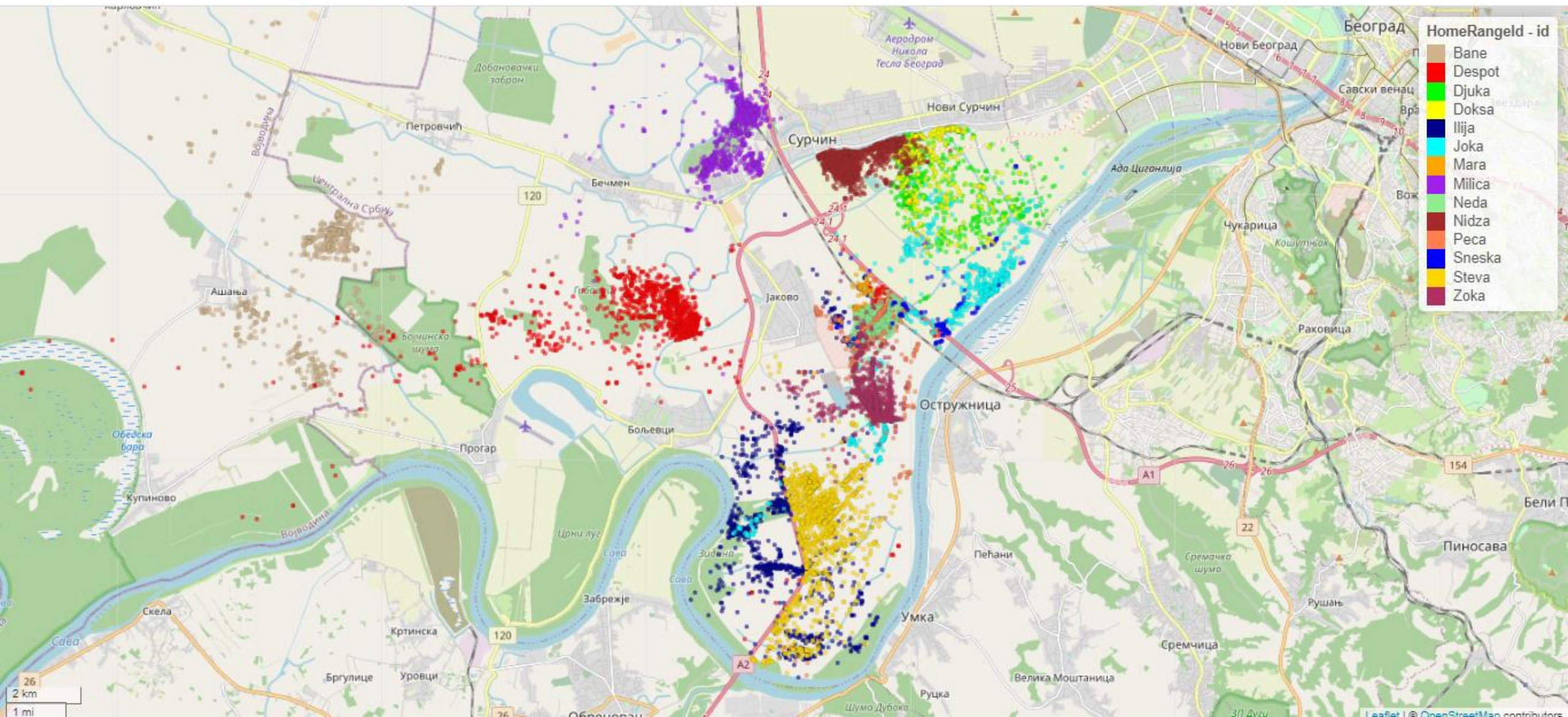
Data analysis - Statistica 10 i R (adehabitatHR package)

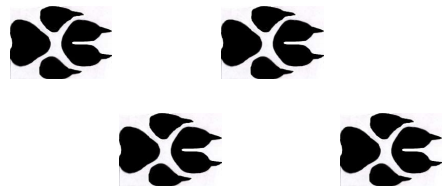


Study area and collared individuals



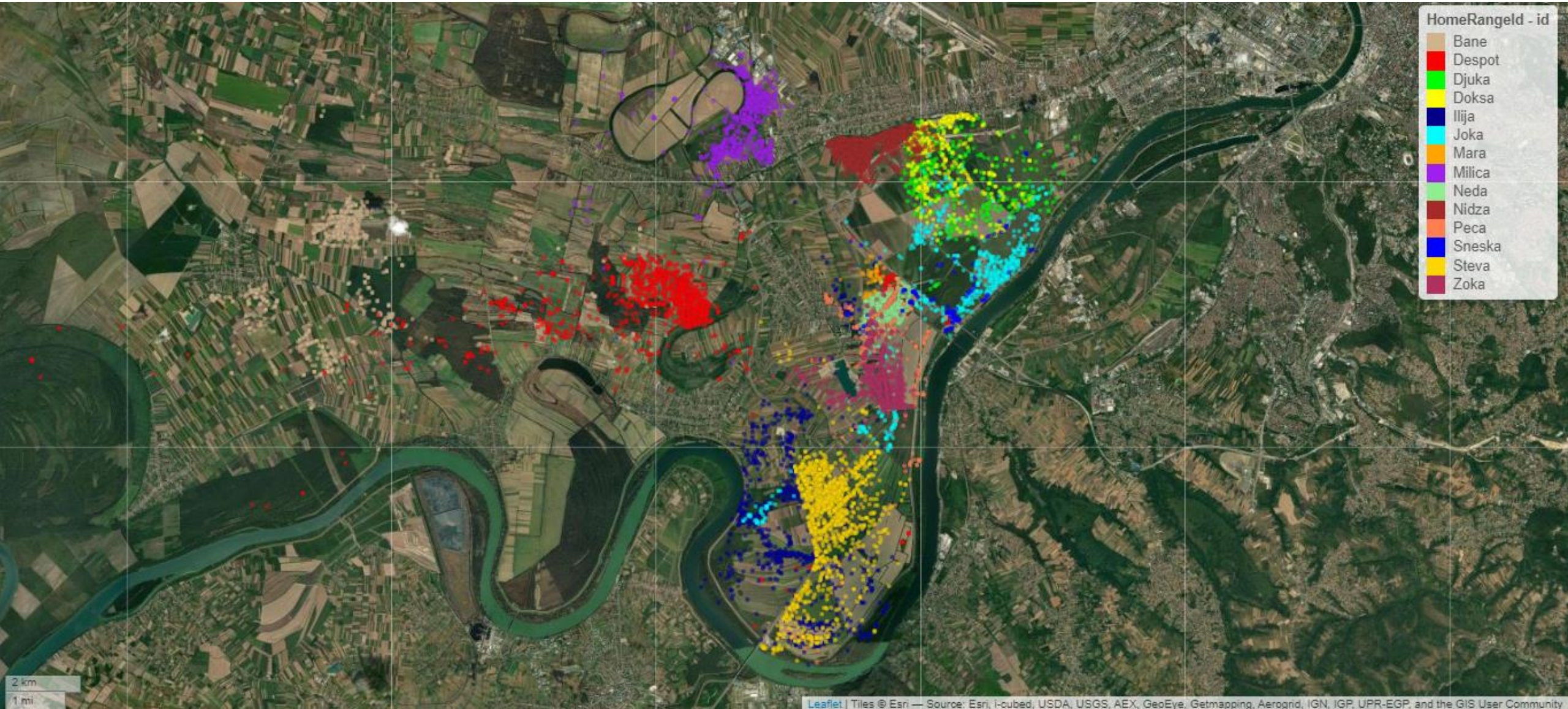
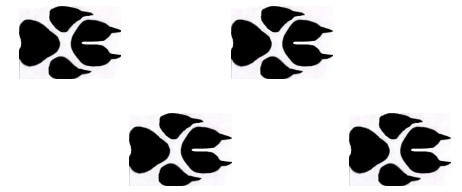
7 females and 7 males over a five year period



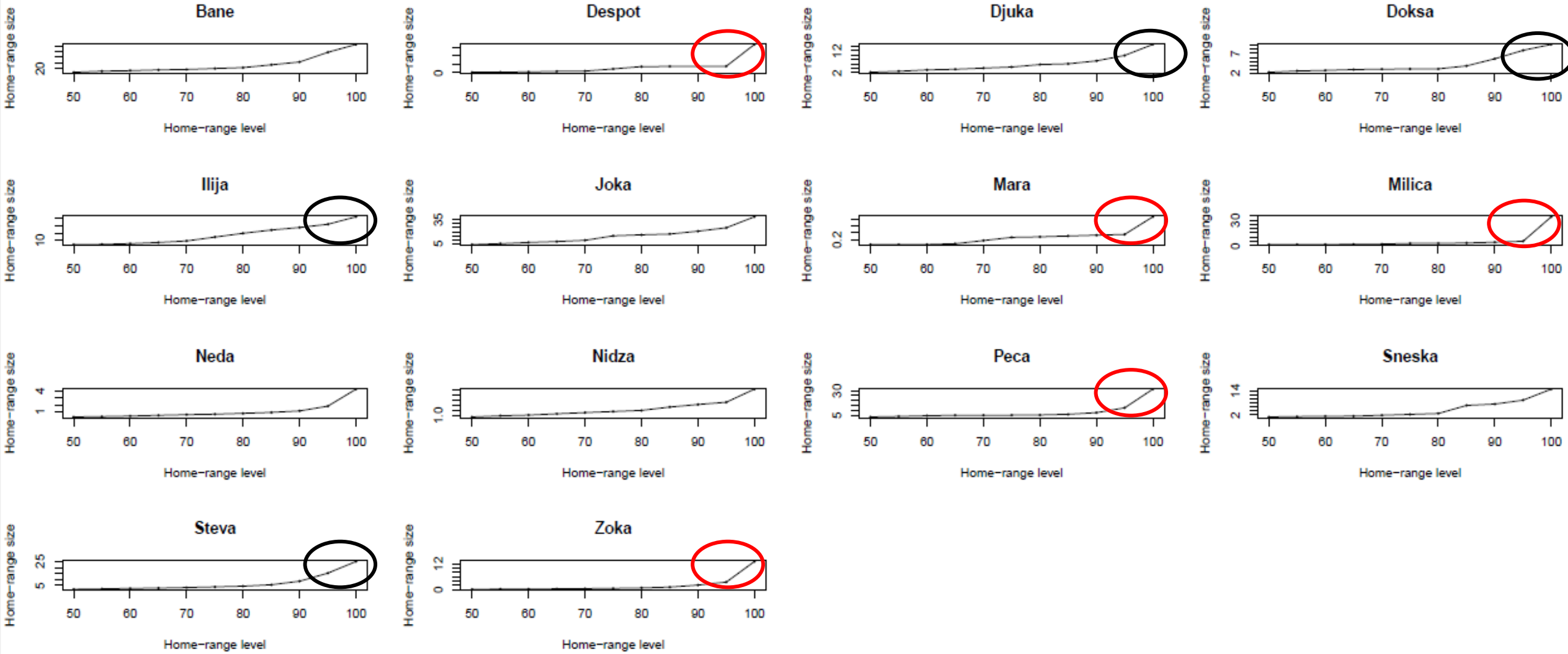


Study area and collared individuals

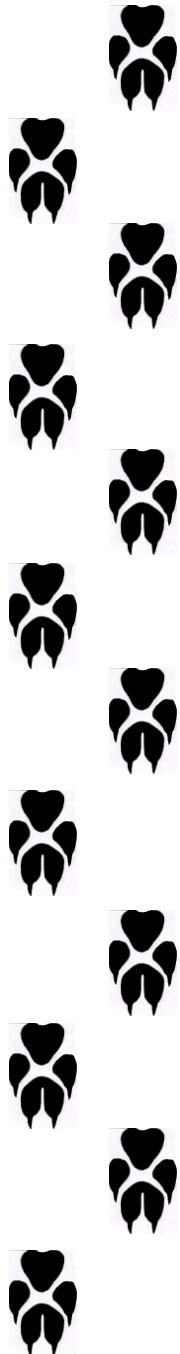
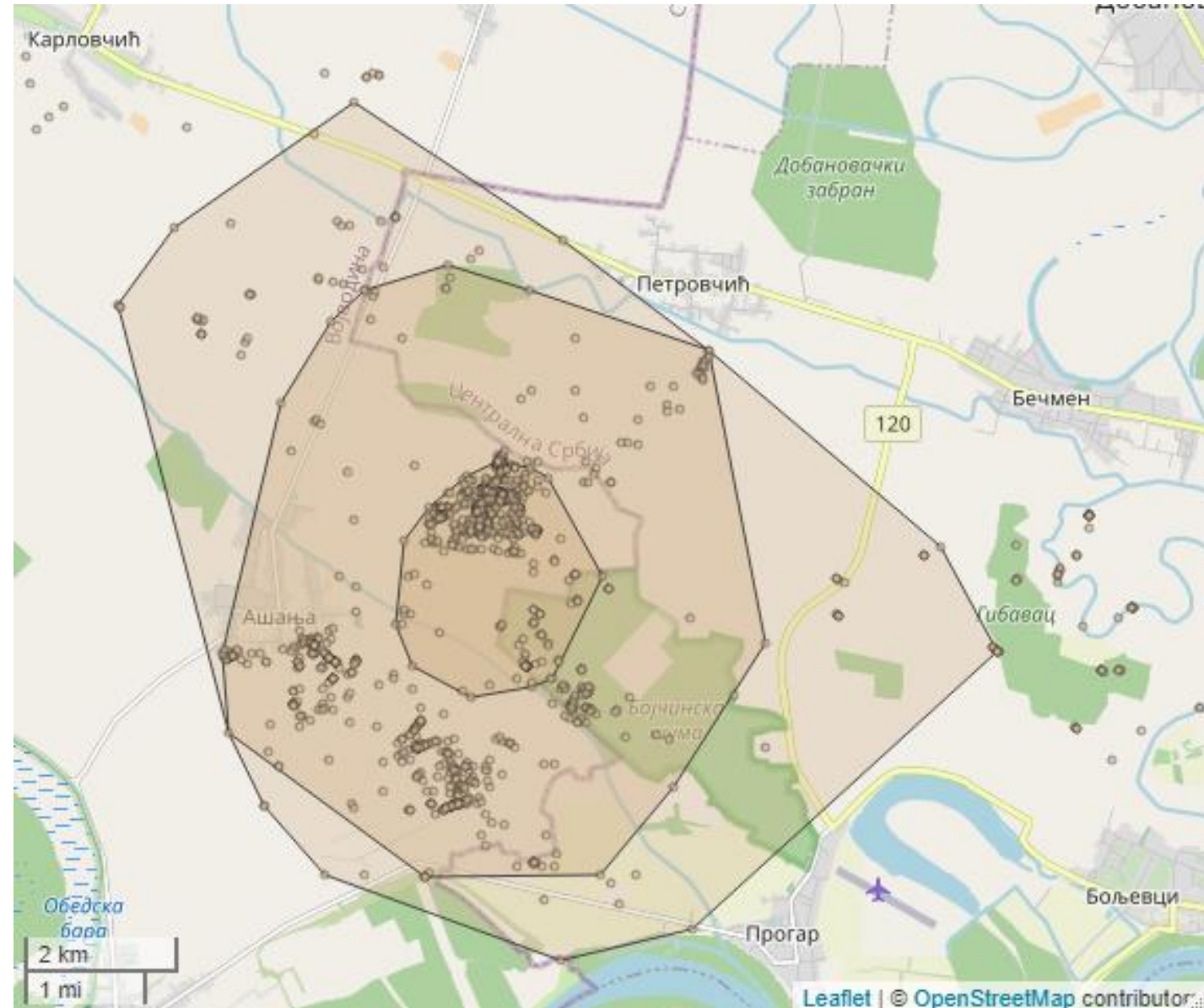
7 females and 7 males over a five year period



Home range size by home range level



M1 - Bane



Sex	Male
Age (est.)	3+ years
Social status	Single
N of days	169
N of fixations	1363
Average daily travel distance (km)	6.37
MCP 95% (km ²)	77.15
MCP 90% (km ²)	43.58
MCP 50% (km ²)	5.91

M2 - Despot

Sex Male

Age (est.) 2 years

Social status Single

N of days 335

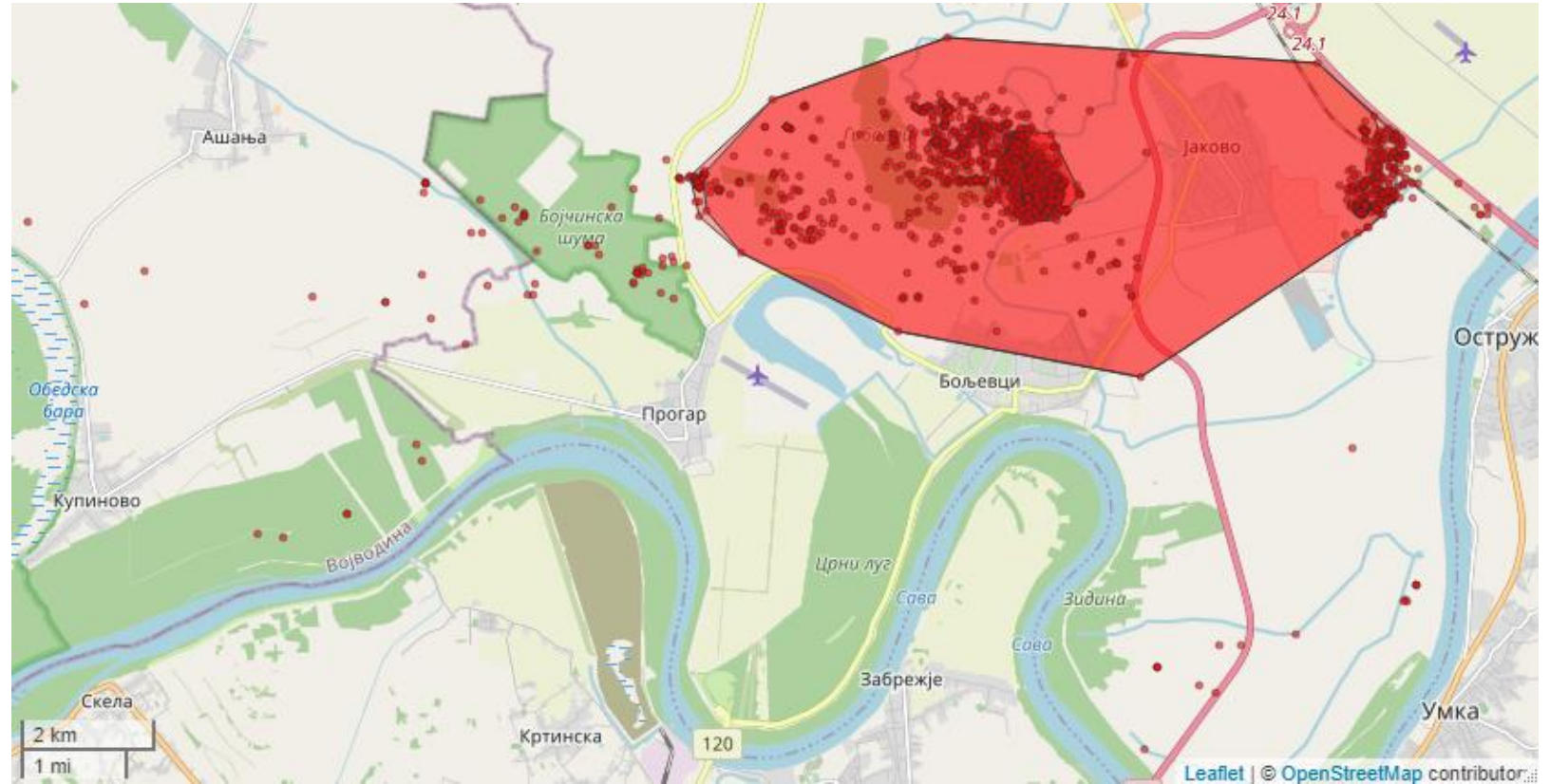
N of fixations 1578

Average daily travel distance (km) 4.57

MCP 95% (km²) 37.28

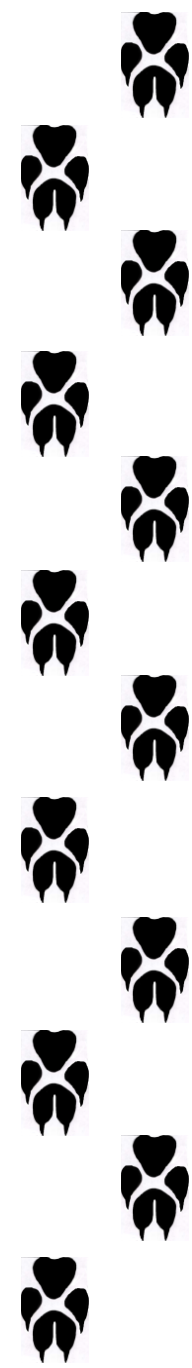
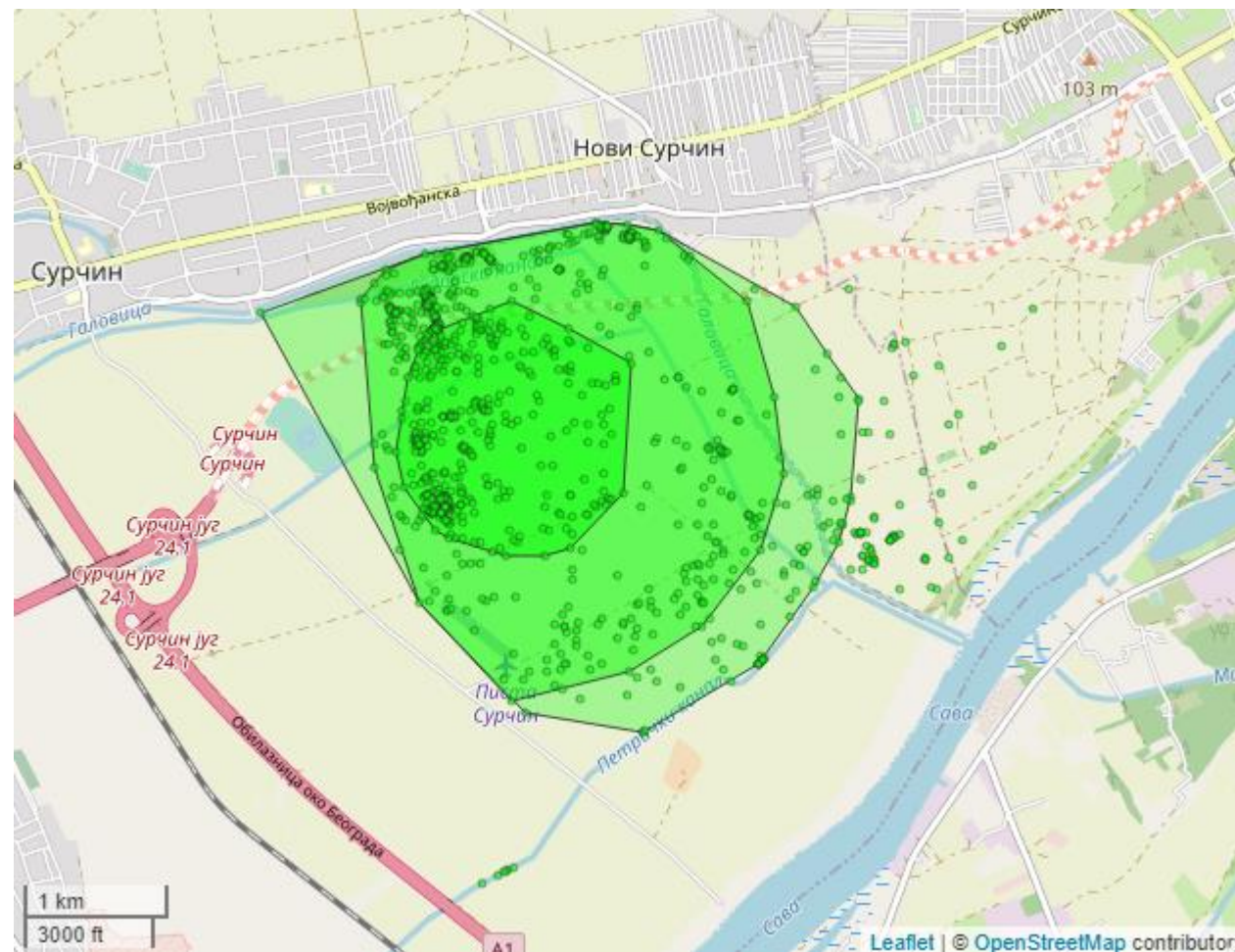
MCP 90% (km²) 36.79

MCP 50% (km²) 1.23



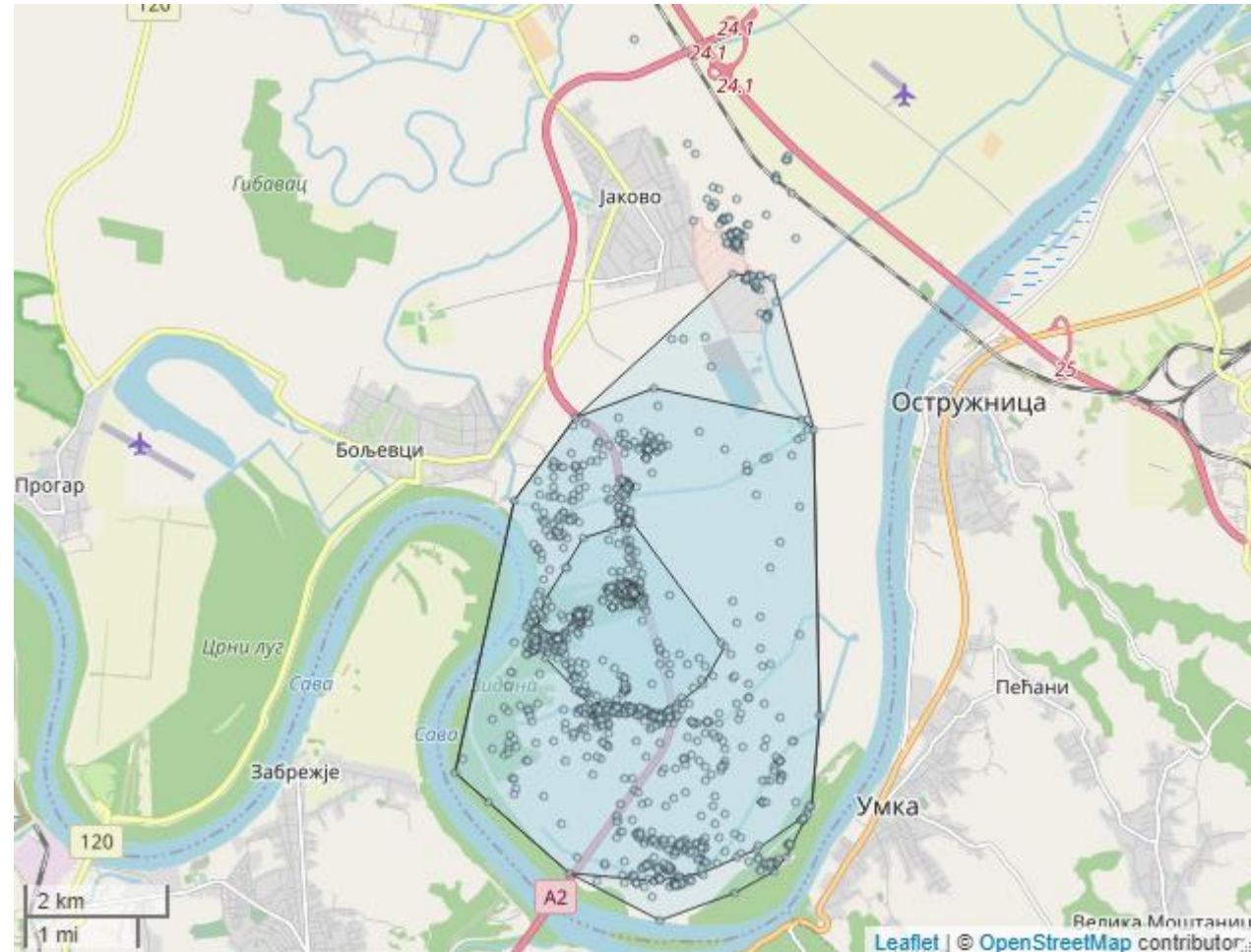
M3 - Djuka

Sex	Male
Age (est.)	subadult
Social status	Paired
N of days	126
N of fixations	1578
Average daily travel distance (km)	5.38
MCP 95% (km ²)	9.89
MCP 90% (km ²)	7.41
MCP 50% (km ²)	2.23



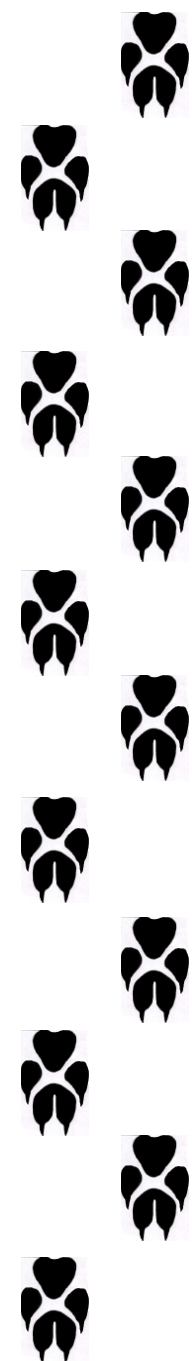
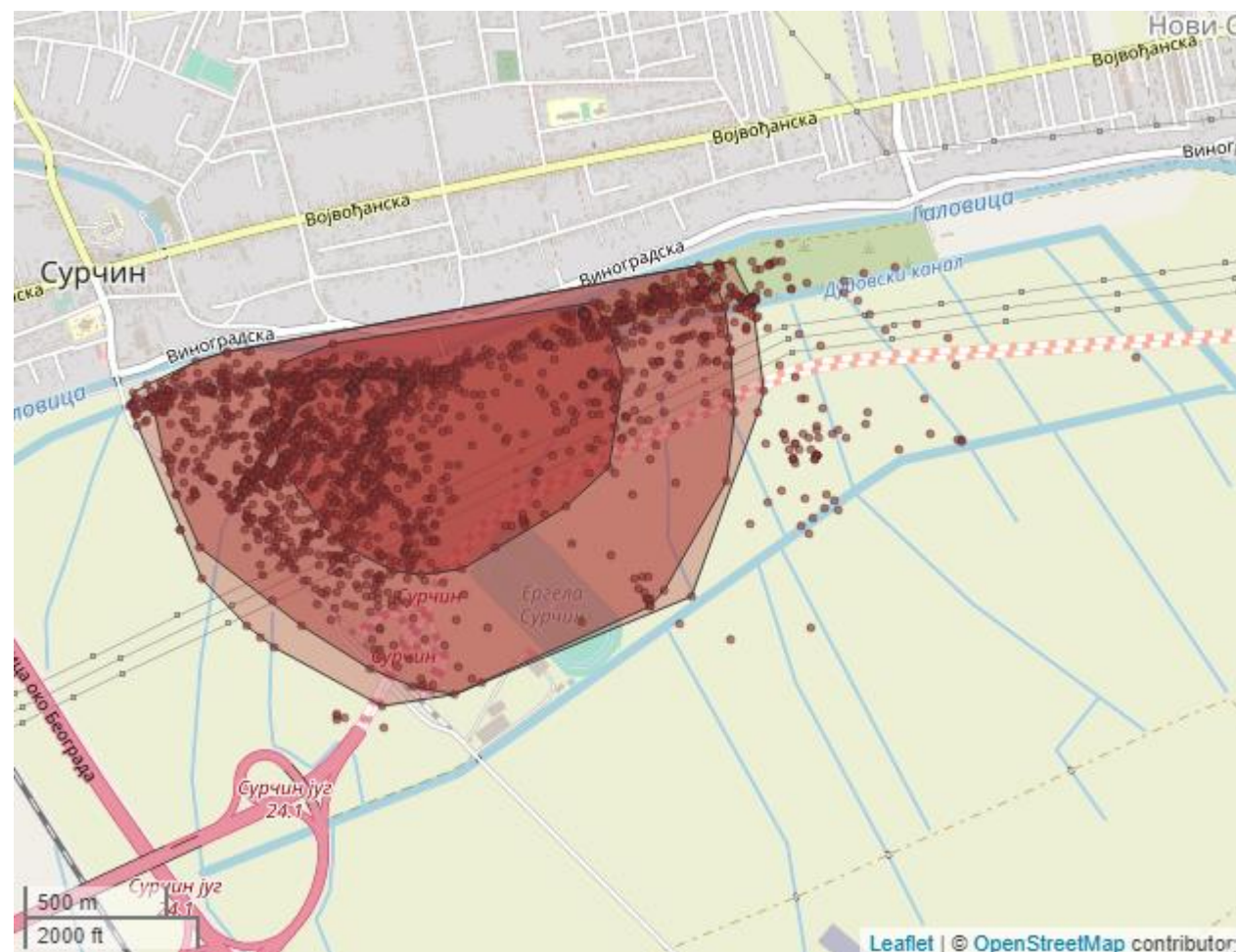
M4 - Ilija

Sex	Male
Age (est.)	2+ years
Social status	Single
N of days	232
N of fixations	2068
Average daily travel distance (km)	5.01
MCP 95% (km ²)	31.66
MCP 90% (km ²)	27.35
MCP 50% (km ²)	4.47



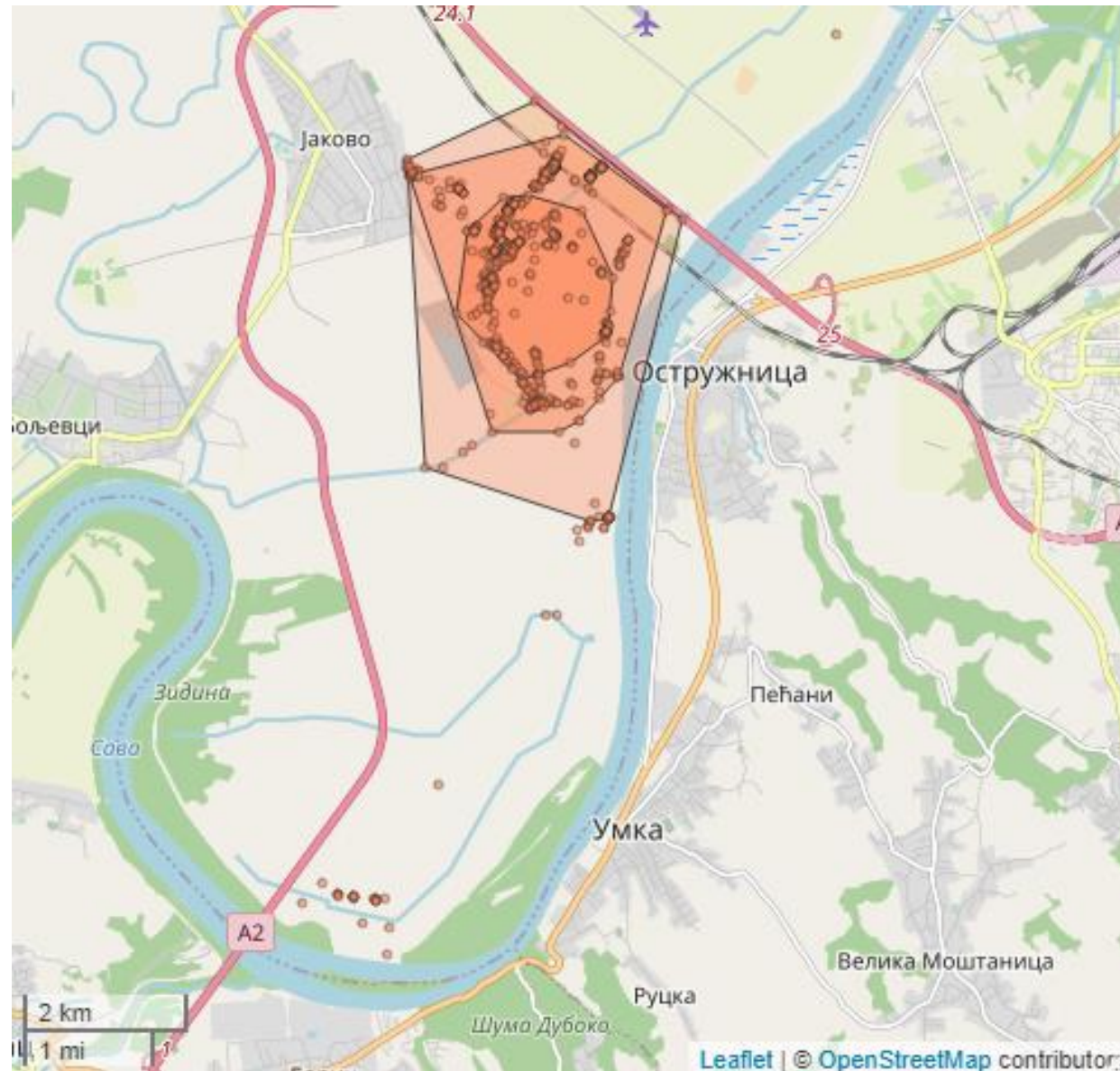
M5 - Nidza

Sex	Male
Age (est.)	3 years
Social status	Paired
N of days	401
N of fixations	3194
Average daily travel distance (km)	3.51
MCP 95% (km ²)	2.31
MCP 90% (km ²)	2.09
MCP 50% (km ²)	0.84



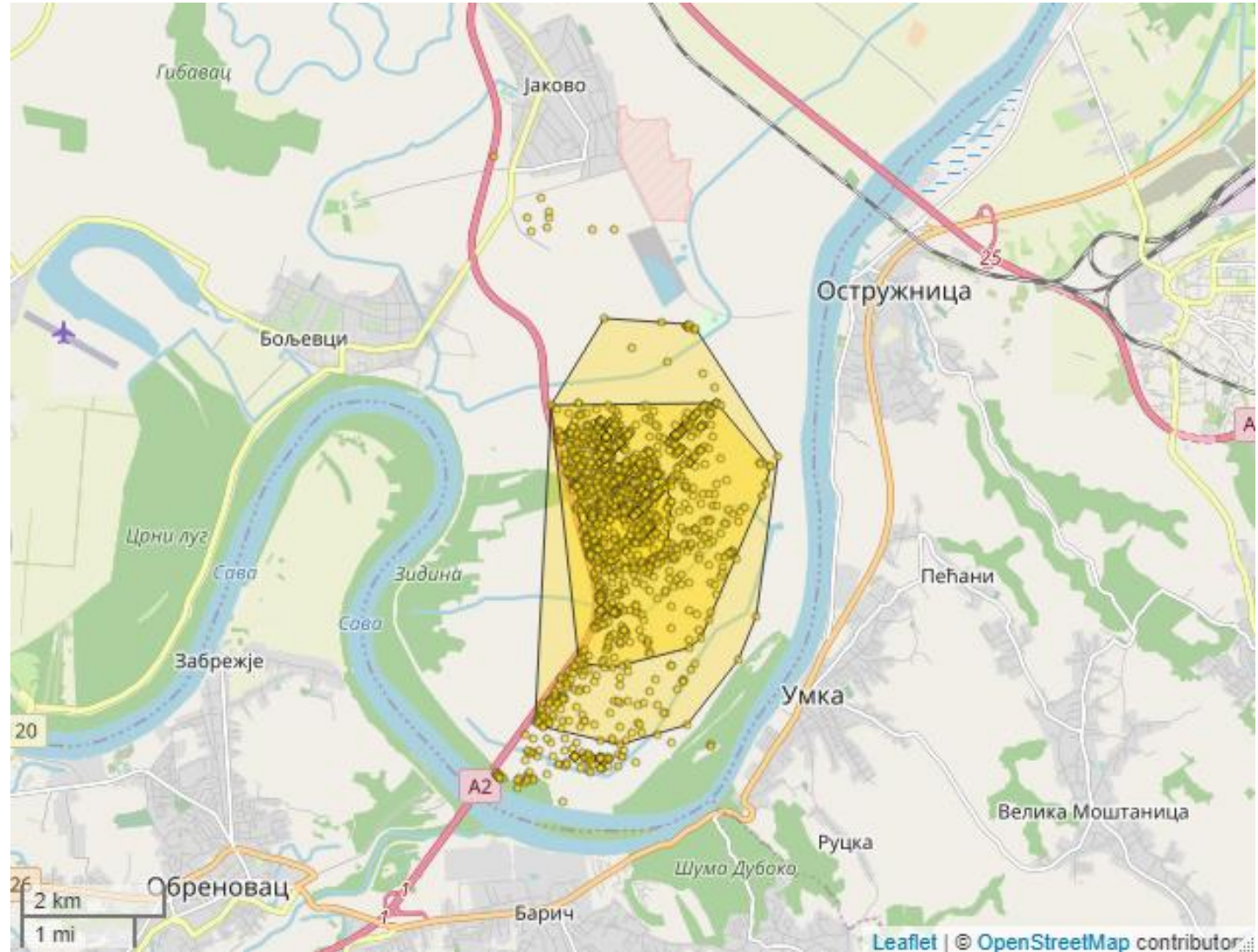
M6 - Песа

Sex	Male
Age (est.)	8 months
Social status	Single
N of days	96
N of fixations	754
Average daily travel distance (km)	3.78
MCP 95% (km ²)	12.44
MCP 90% (km ²)	7.54
MCP 50% (km ²)	3.15



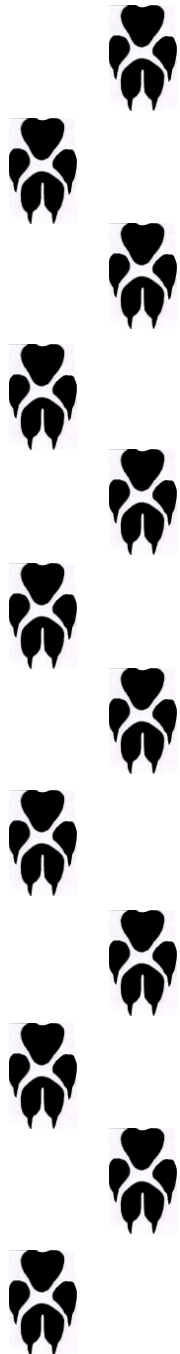
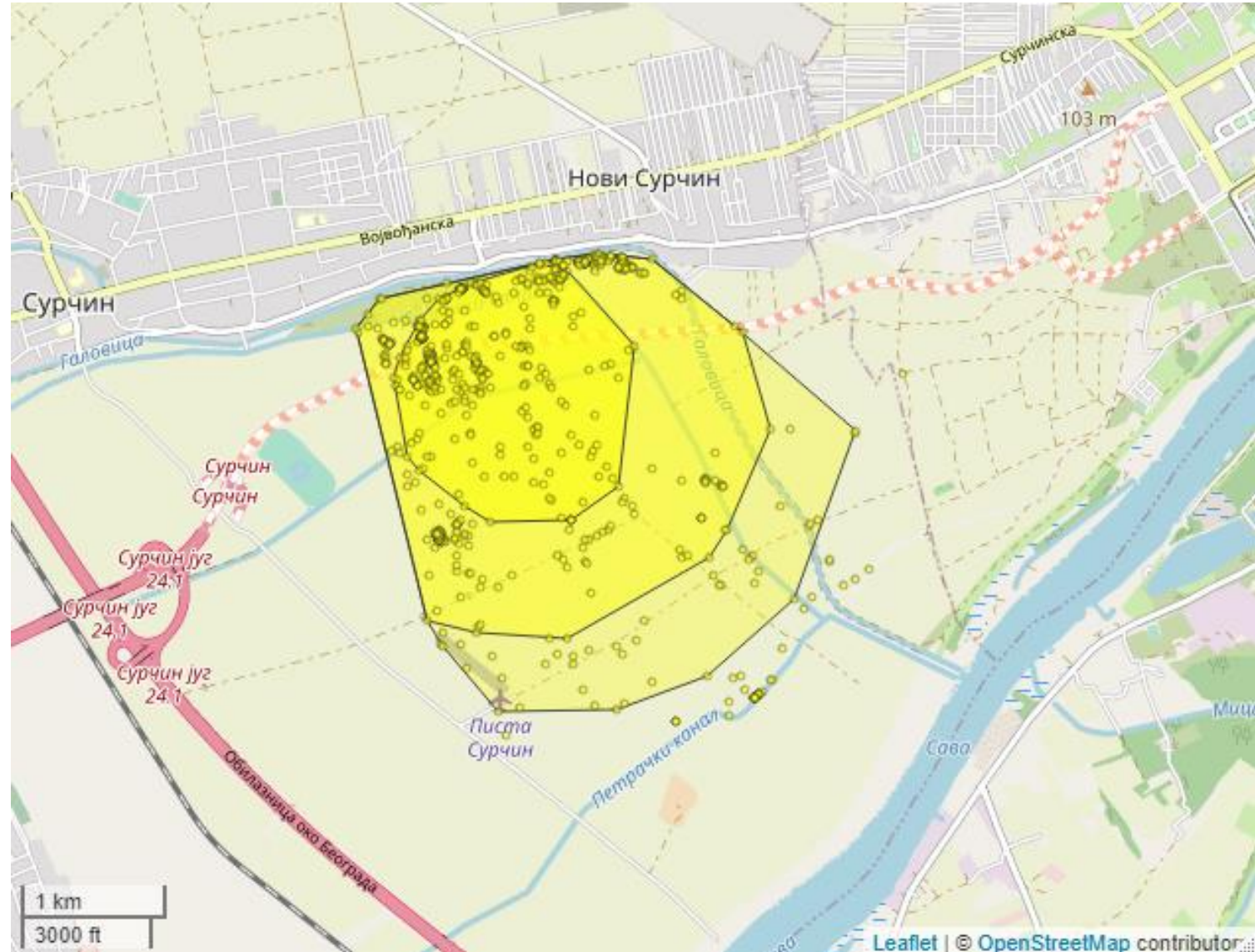
M7 - Steva

Sex	Male
Age (est.)	2 years
Social status	Single
N of days	338
N of fixations	2675
Average daily travel distance (km)	4.73
MCP 95% (km ²)	15.19
MCP 90% (km ²)	8.35
MCP 50% (km ²)	1.49



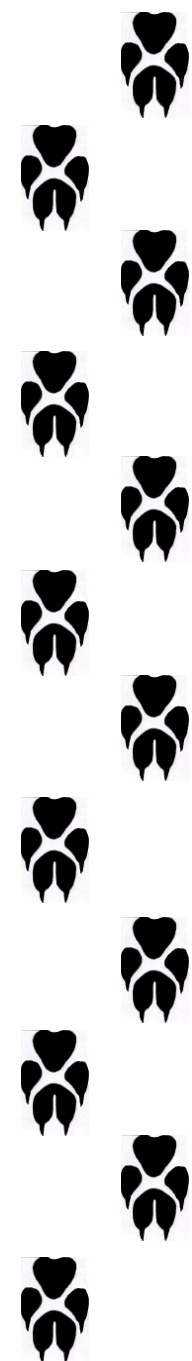
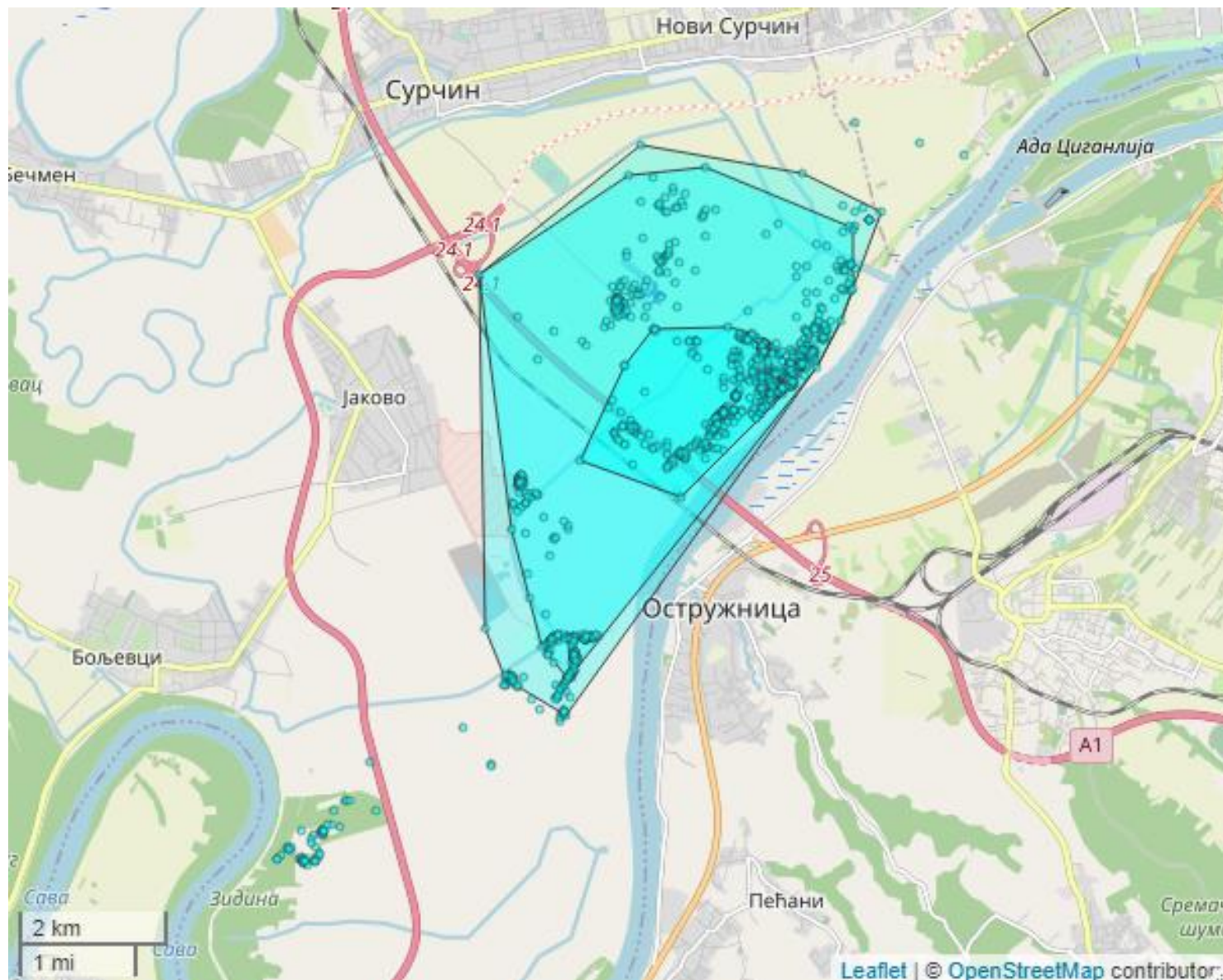
F1 - Doksa

Sex	Female
Age (est.)	subadult
Social status	Paired
N of days	127
N of fixations	879
Average daily travel distance (km)	4.24
MCP 95% (km ²)	7.77
MCP 90% (km ²)	5.66
MCP 50% (km ²)	2.28



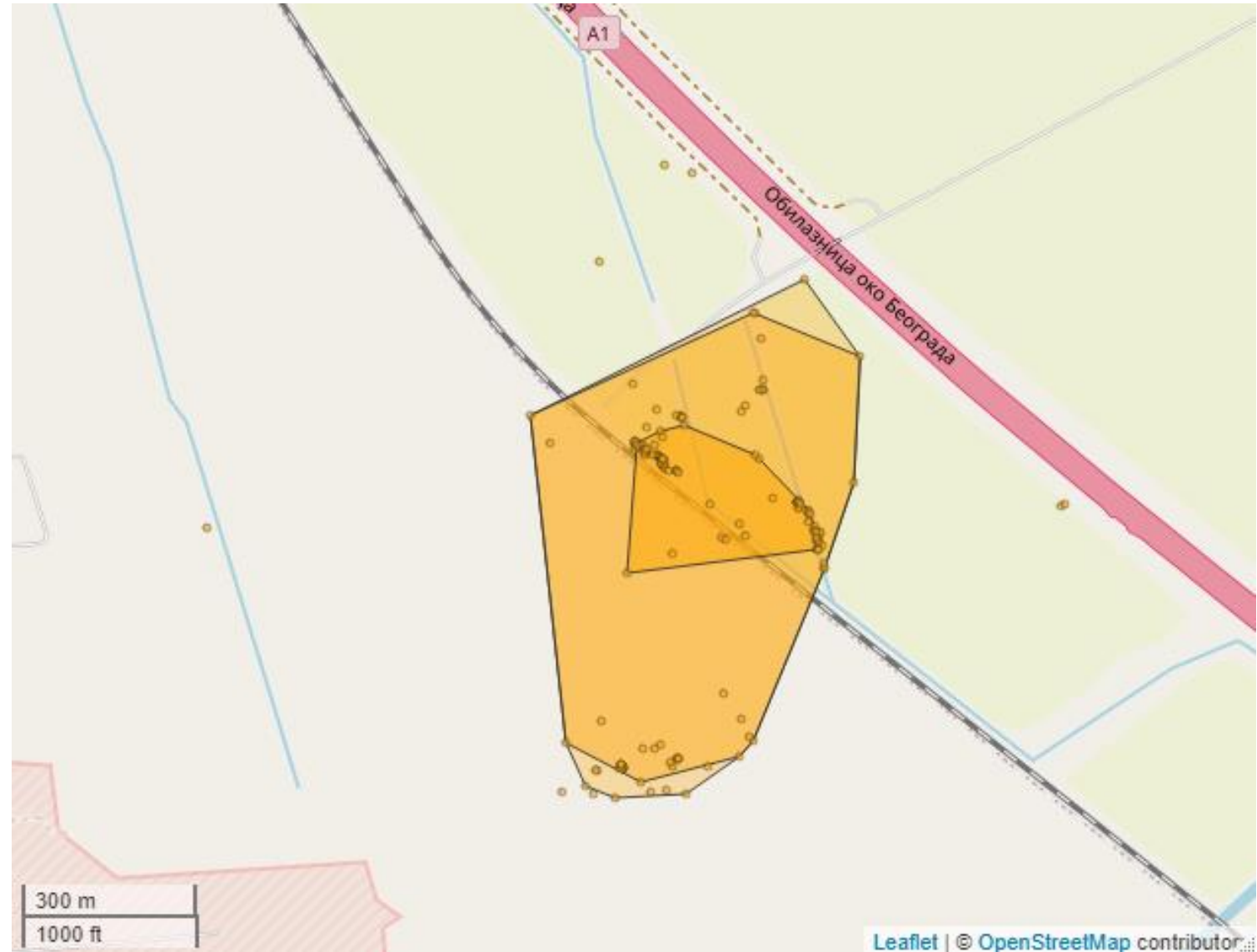
F2 - Joka

Sex	Female
Age (est.)	11 months
Social status	Single
N of days	168
N of fixations	1340
Average daily travel distance (km)	2.48
MCP 95% (km ²)	24.88
MCP 90% (km ²)	20.66
MCP 50% (km ²)	4.08



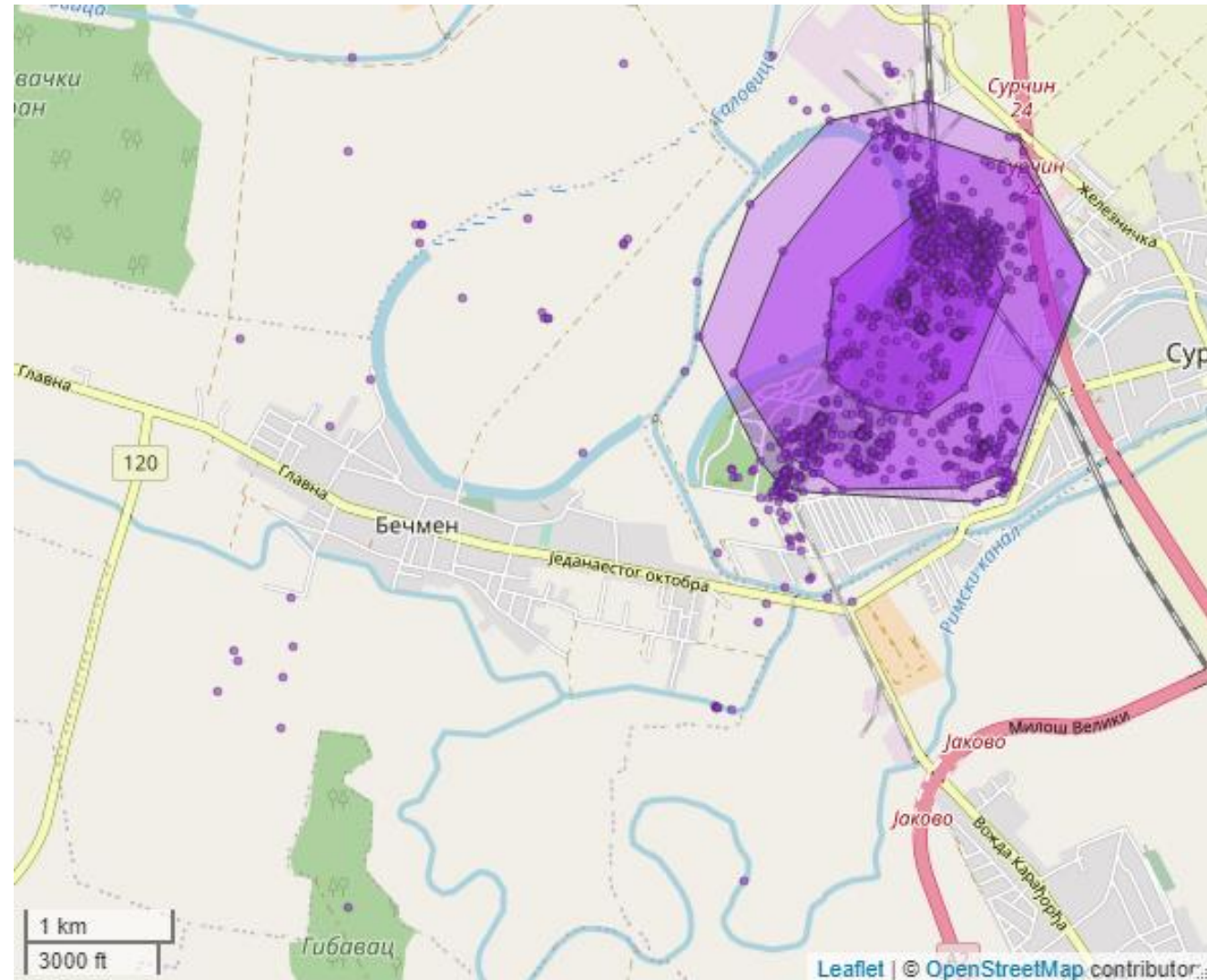
F3 - Mara

Sex	Female
Age (est.)	7 months
Social status	Single
N of days	20
N of fixations	158
Average daily travel distance (km)	1.61
MCP 95% (km ²)	0.35
MCP 90% (km ²)	0.33
MCP 50% (km ²)	0.06

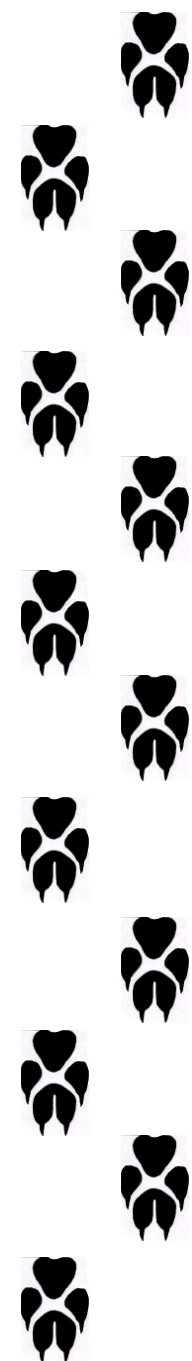
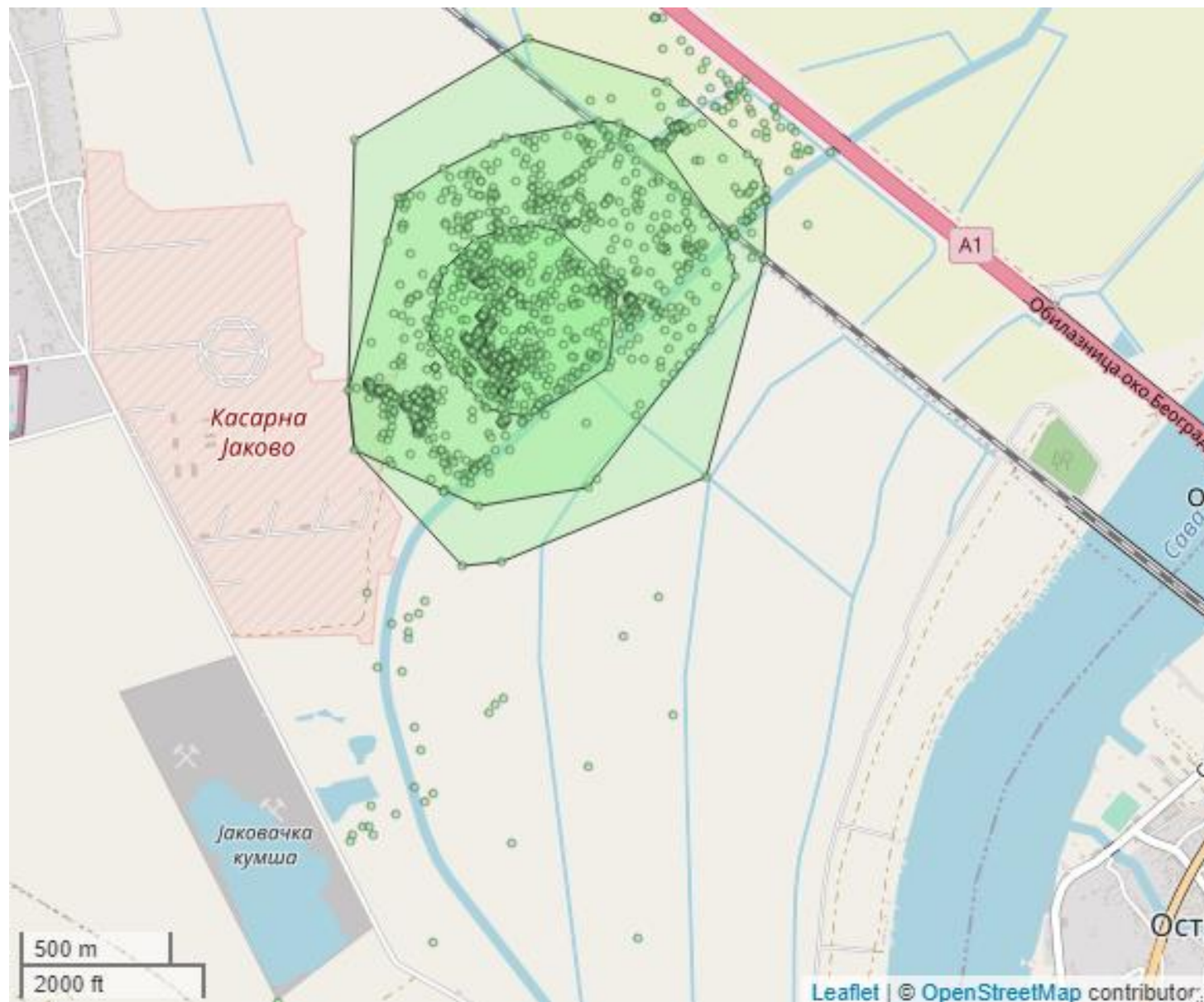


F4 - Milica

Sex	Female
Age (est.)	2 years
Social status	Single
N of days	268
N of fixations	2206
Average daily travel distance (km)	3.32
MCP 95% (km ²)	5.09
MCP 90% (km ²)	3.97
MCP 50% (km ²)	1.16



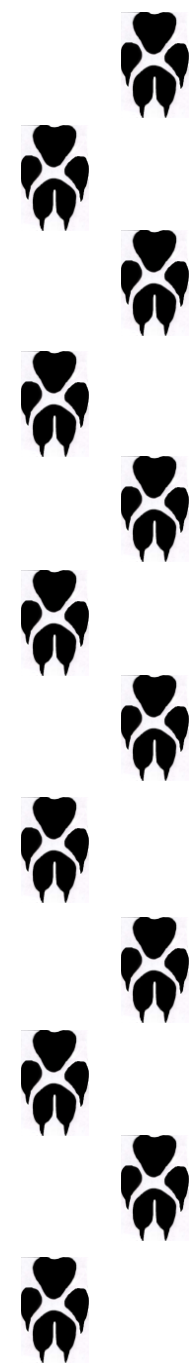
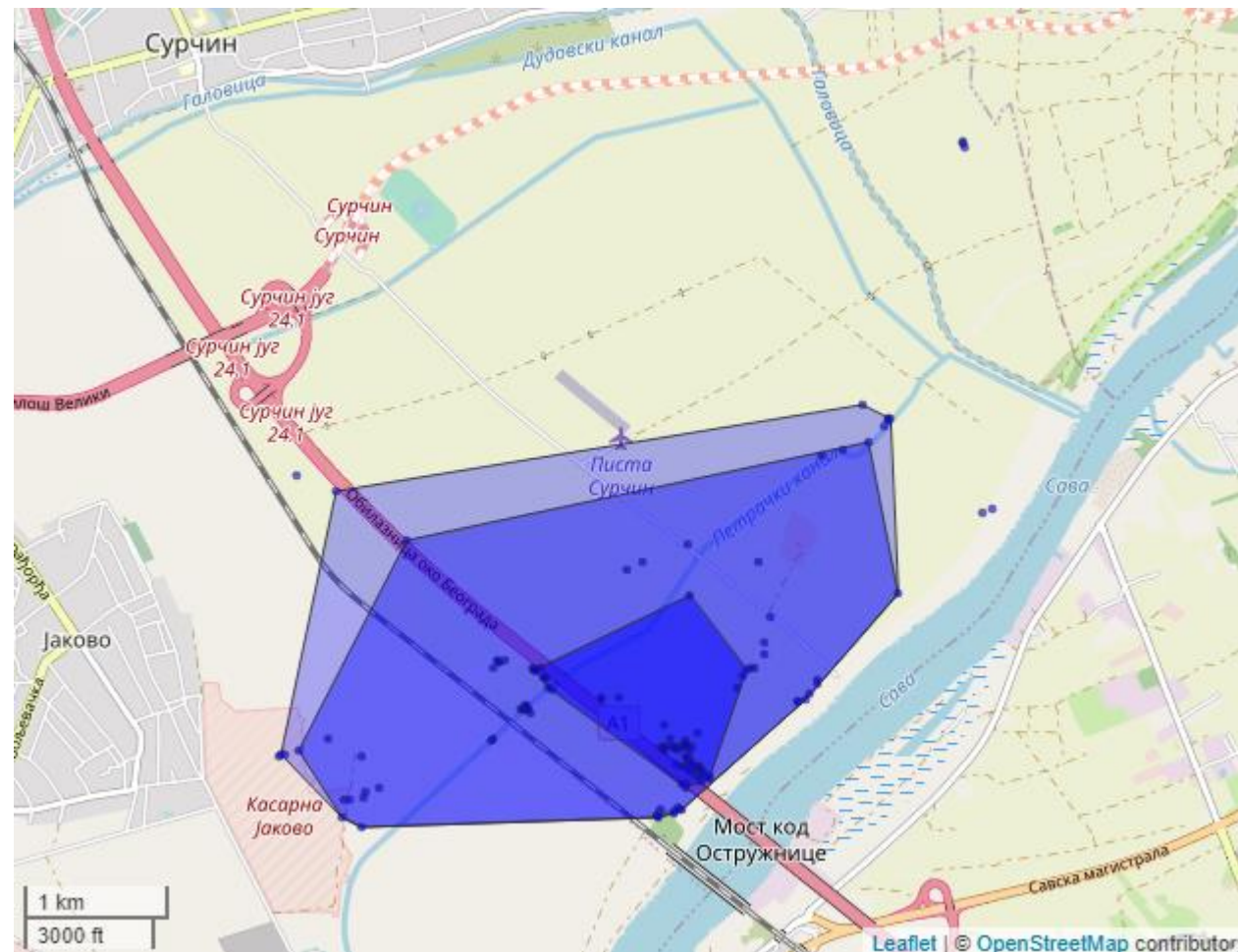
F5 - Neda

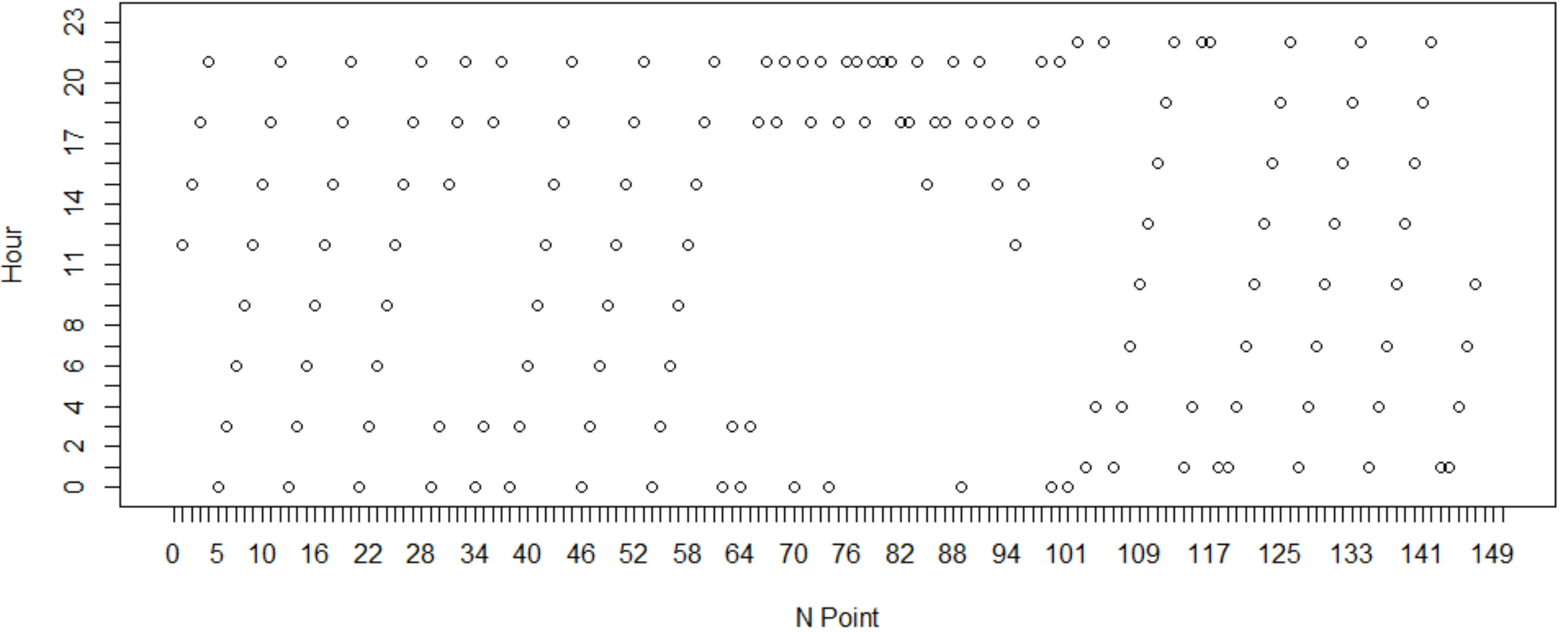


Sex	Female
Age (est.)	2 years
Social status	Paired
N of days	222
N of fixations	1746
Average daily travel distance (km)	3.21
MCP 95% (km ²)	1.83
MCP 90% (km ²)	1.15
MCP 50% (km ²)	0.29

F6 - Sneska

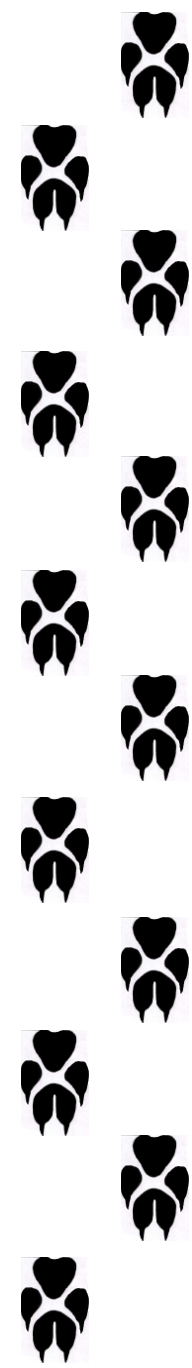
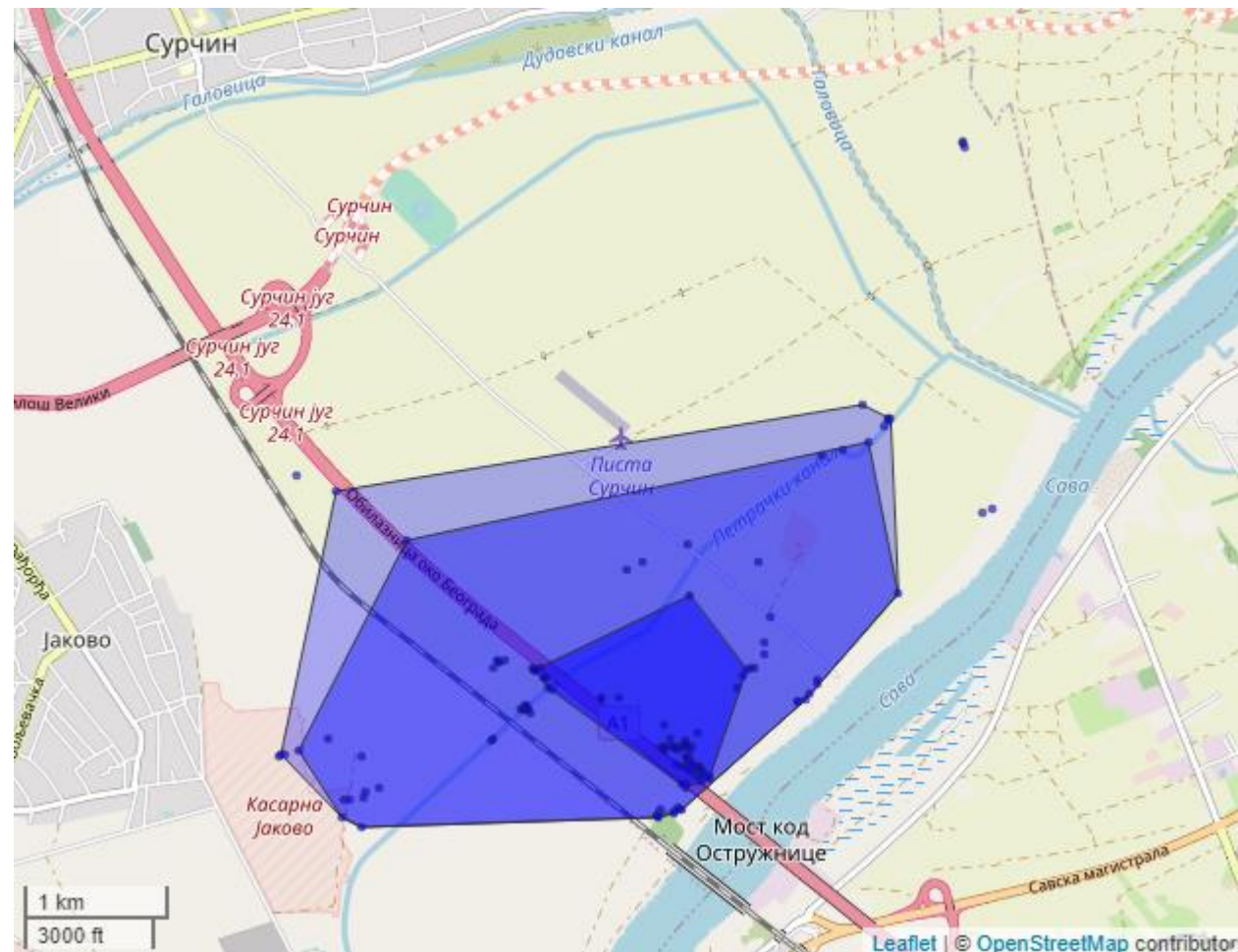
Sex	Female
Age (est.)	subadult
Social status	Single
N of days	60
N of fixations	201
Average daily travel distance (km)	4.27
MCP 95% (km ²)	9.31
MCP 90% (km ²)	7.39
MCP 50% (km ²)	1.05





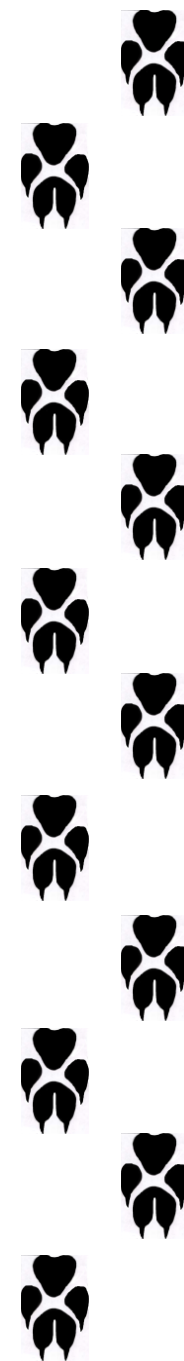
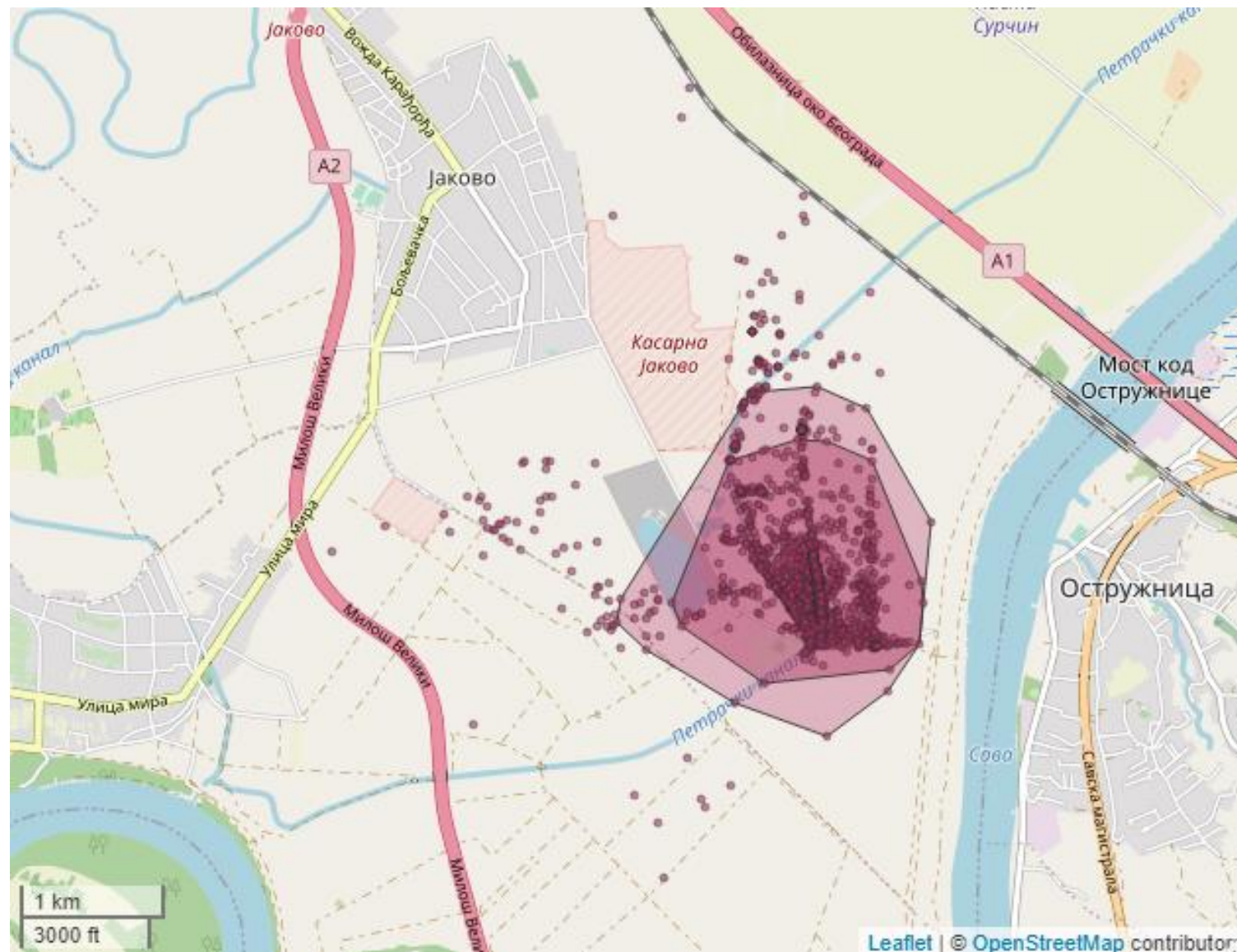
F6 - Sneska

Sex	Female
Age (est.)	subadult
Social status	Single
N of days	60
N of fixations	201
Average daily travel distance (km)	4.27
MCP 95% (km ²)	9.31
MCP 90% (km ²)	7.39
MCP 50% (km ²)	1.05



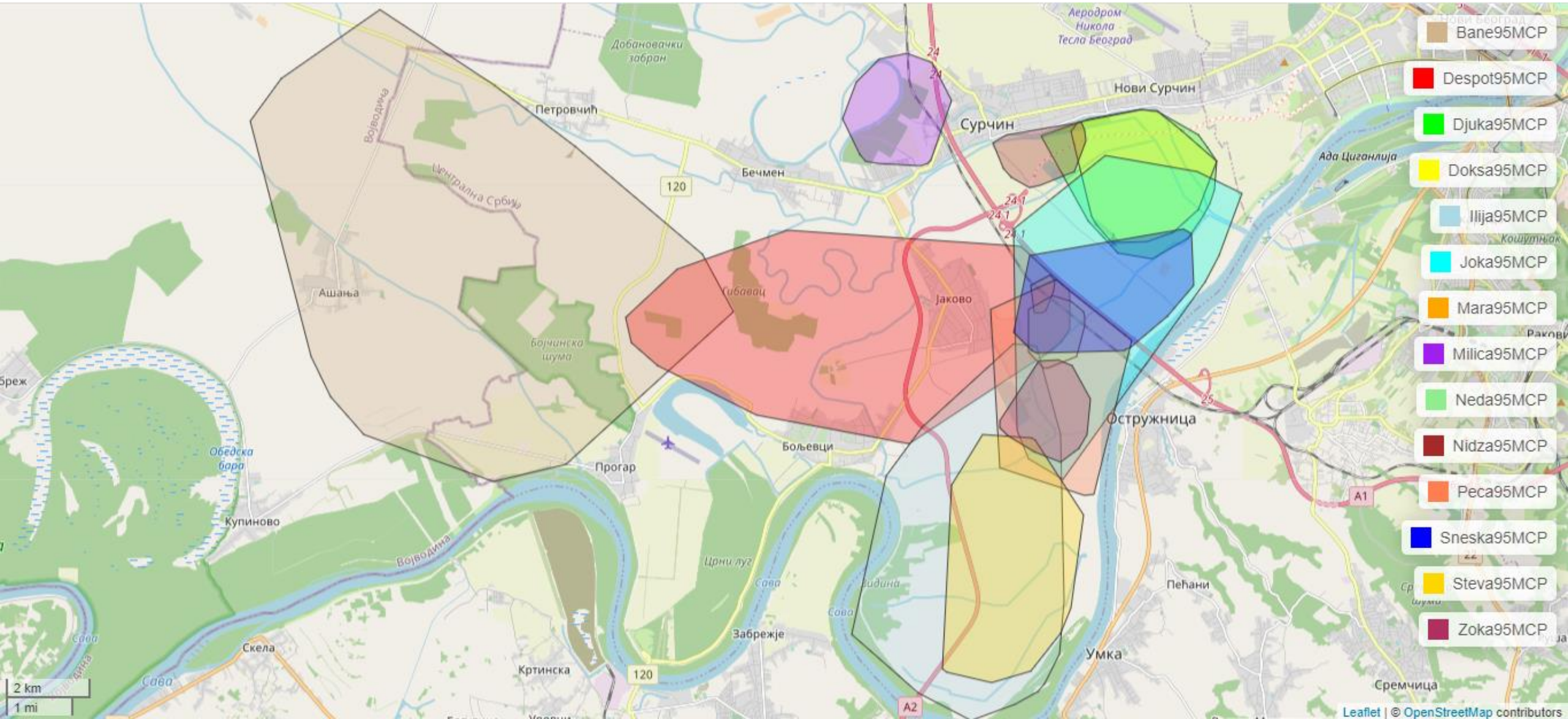
F7 - Zoka

Sex	Female
Age (est.)	1 year
Social status	Single
N of days	327
N of fixations	1363
Average daily travel distance (km)	3.16
MCP 95% (km ²)	3.54
MCP 90% (km ²)	2.17
MCP 50% (km ²)	0.21



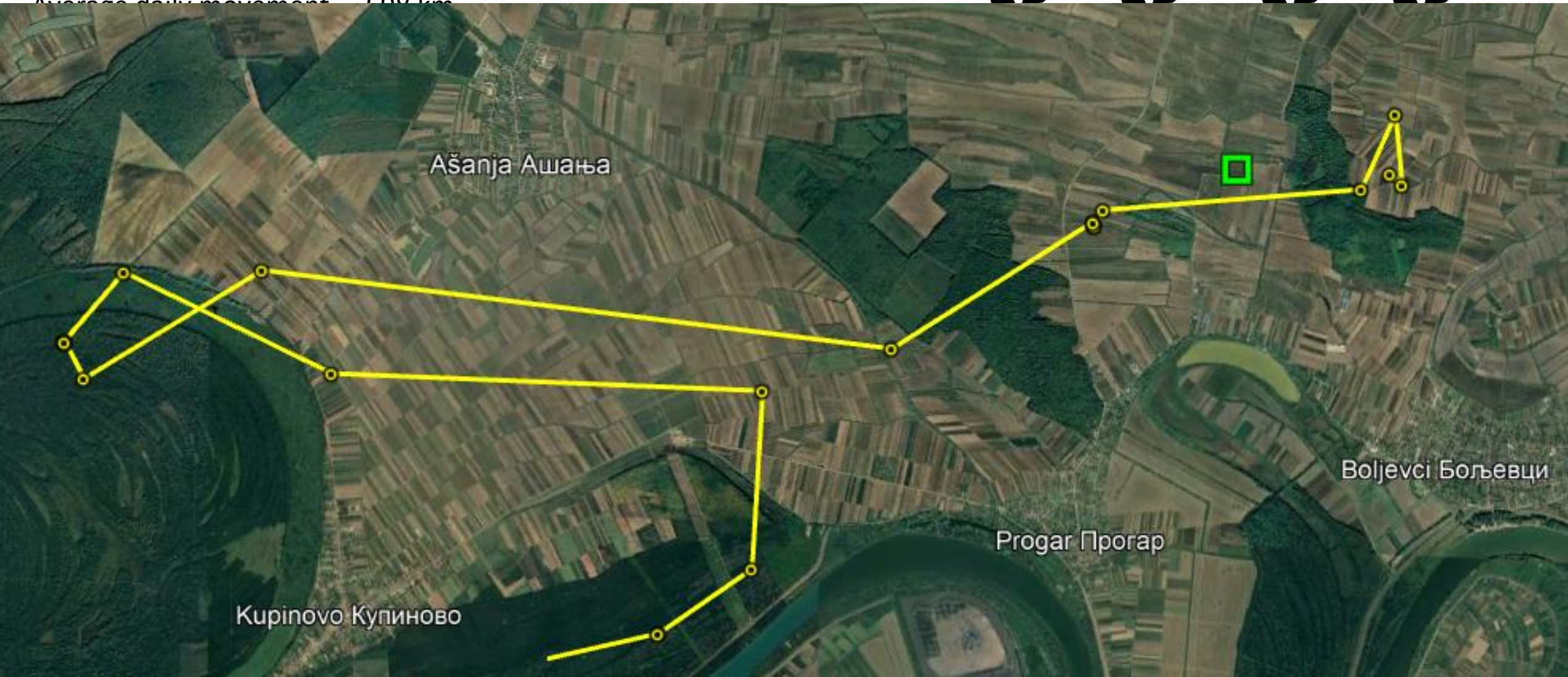


Overview – MCP at 95%



Summary of movements and Home range

Average daily movement – 2.08 km



Average male home range at 95% MCP – 26.56 km²

Distance sred ukupno: KW-H(1,14) = 6.8612, p = 0.0088

□ 25%-75%
┌ Non-Outlier Range
○ Outliers
* Extremes

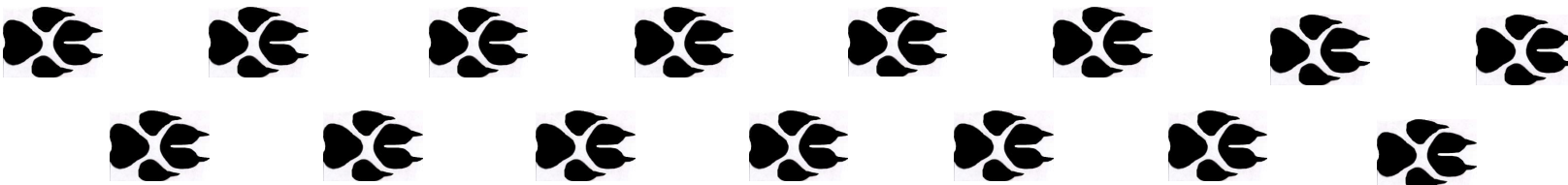
Daytime home range dynamics

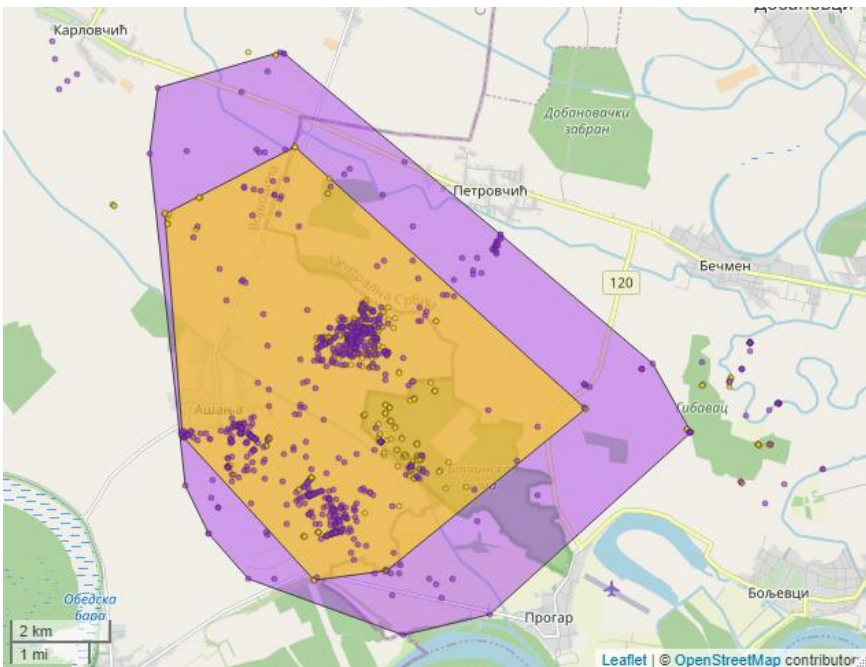
🐾 Average daytime home range was 10.7 km², 16.02 km² for males and 5.37 km² for females, whereas nighttime home range average was 16.84 km², 26.72 km² for males and 6.95 km² for females.

🐾 All individuals have a larger nighttime home range compared to daytime.

🐾 Nighttime home ranges were on average 1.69 times larger than daytime home ranges, 1.54 times larger for males and 1.82 larger for females.

Jackal	95% MPC day (km ²)	95% MPC night (km ²)
Bane M1	42.31	79.48
Despot M2	22.27	37.21
Djuka M3	7.75	9.30
Doksa F1	6.89	7.06
Ilija M4	17.44	32.35
Joka F2	19.50	23.37
Mara F3	0.11	0.36
Milica F4	3.48	5.14
Neda F5	0.94	1.95
Nidža M5	1.43	2.39
Peca M6	8.65	12.44
Sneska F6	4.93	6.27
Steva M7	12.29	13.88
Zoka F7	1.77	4.53





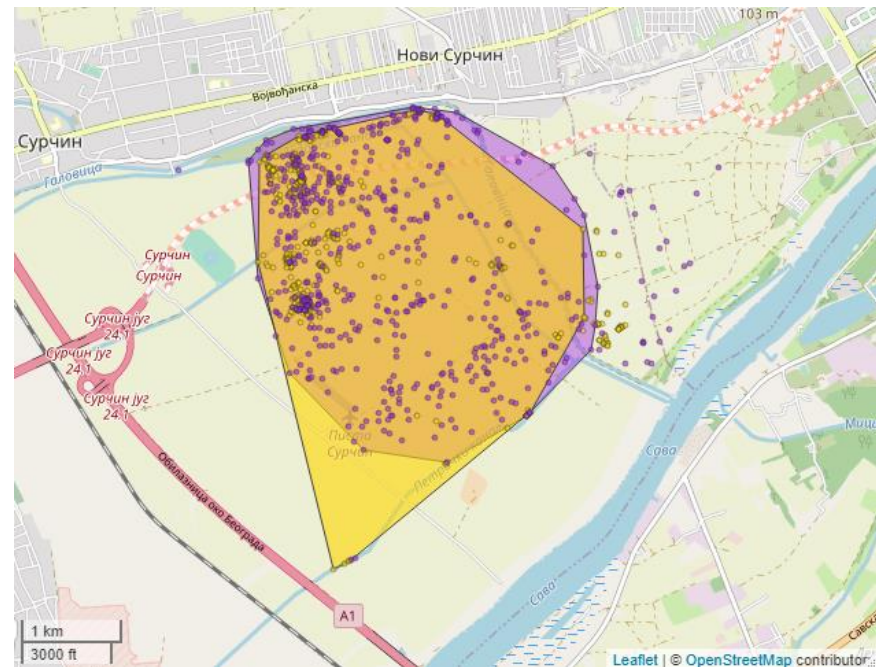
Largest difference

Nighttime home range
VS
Daytime home range

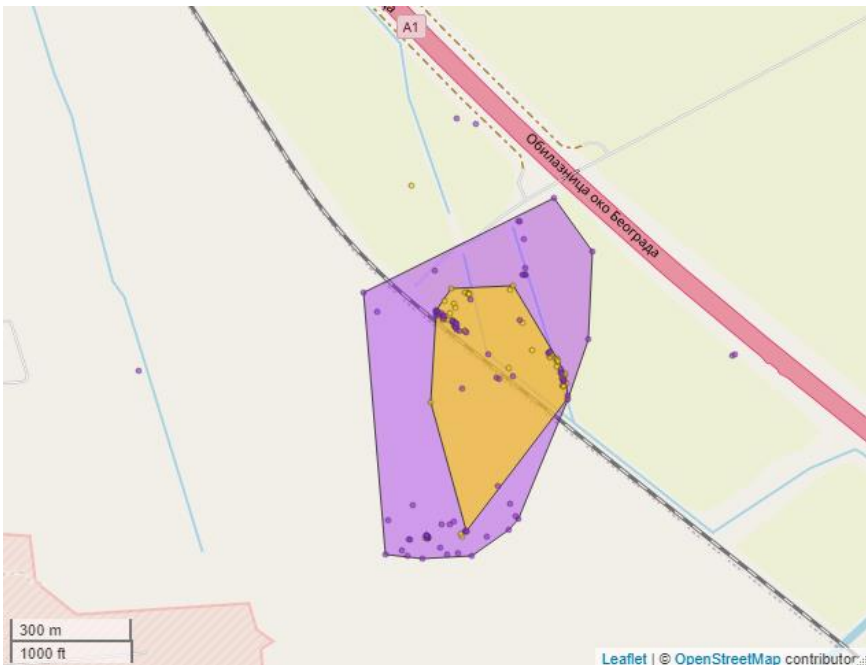
Bane M1 – 1.88



Djuka M3 – 1.20



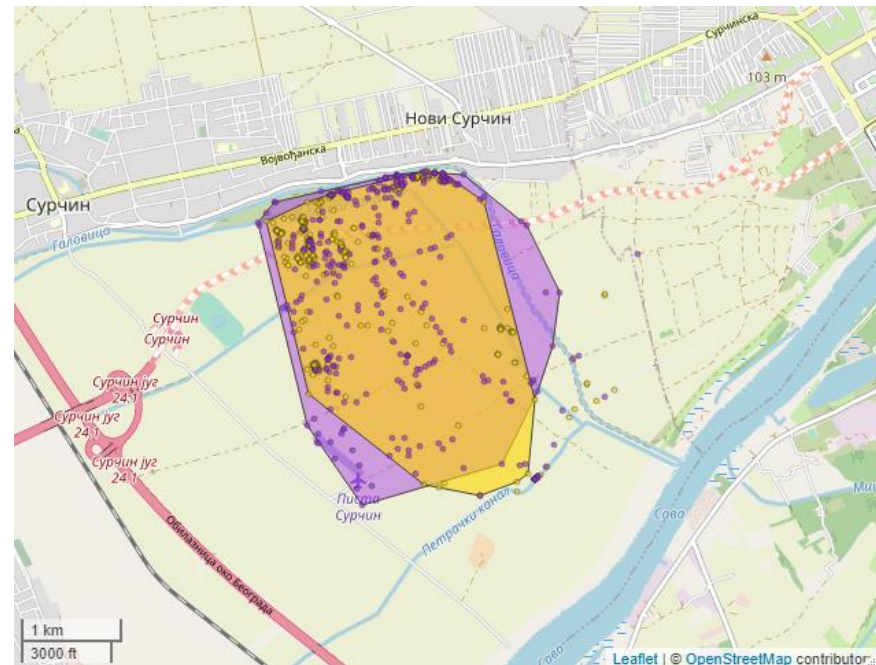
Smallest difference




Mara F3 – 3.17





Doksa F1 - 1.02




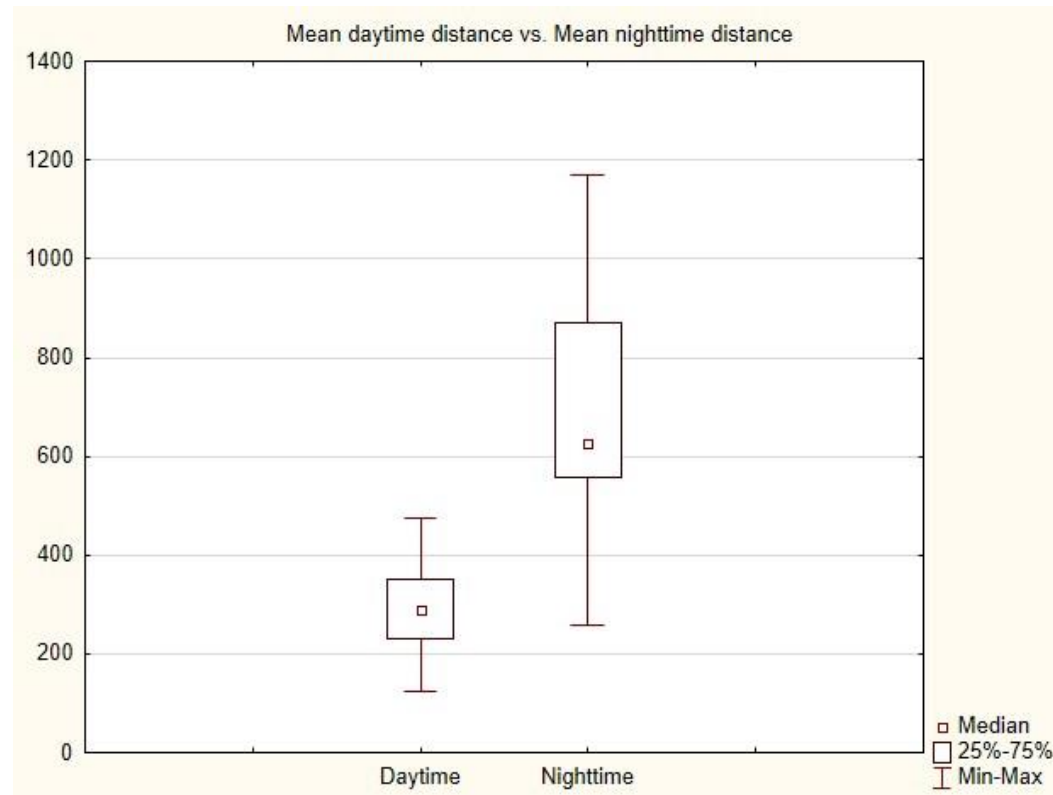
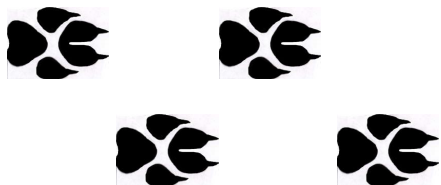
Daytime movement dynamics

 Average daytime movement distance (for 3h) was 299 m and 700 m for nighttime movements.

 Nighttime movement distances (for 3h) were 2.38 times longer than daytime distances, 2.7 for males, and 2.07 for females.

 Males have significantly longer movement distances during night ($t=3.24, p<0.05$), but no significant difference for daytime movements.

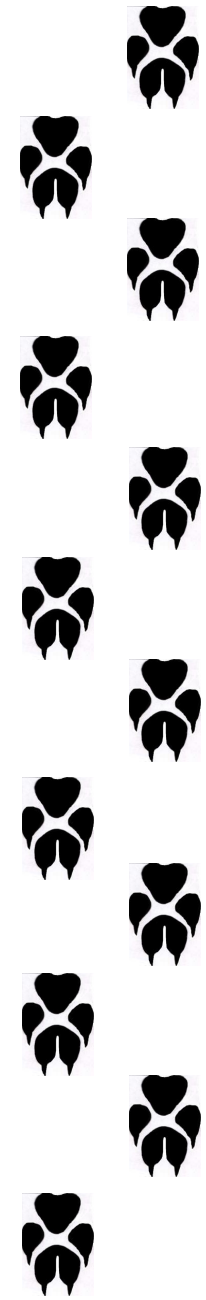
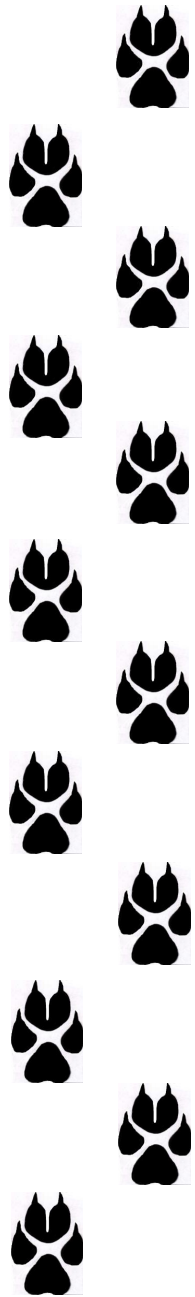
 Significant difference between daytime and nighttime movements for all jackals ($t(14)= -6.8, p <0.001$). Similar results for males ($t(7)= -6.8, p <0.001$) and females ($t(7)= -5.3, p <0.001$). But no significant differences between the sexes when it comes to daytime vs nighttime movements.



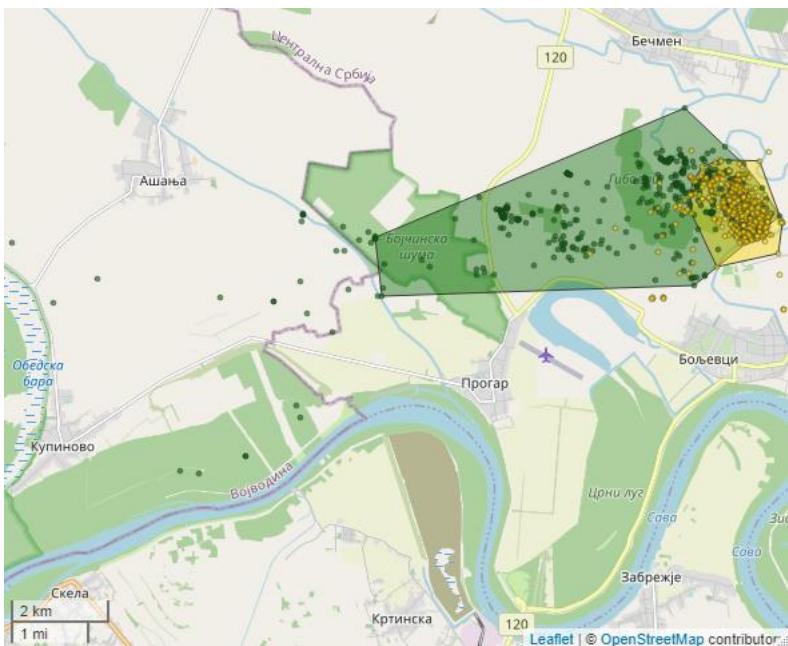
Jackal	Movement distance per 3h day (m)	Movement distance per 3h night (m)
Bane M1	474	1076
Despot M2	299	869
Djuka M3	315	1168
Doksa F1	350	765
Ilija M4	280	1003
Joka F2	280	359
Mara F3	125	258
Milica F4	213	623
Neda F5	262	535
Nidža M5	303	587
Peca M6	230	631
Sneska F6	395	599
Steva M7	432	762
Zoka F7	228	559

Seasonal dynamics of home ranges

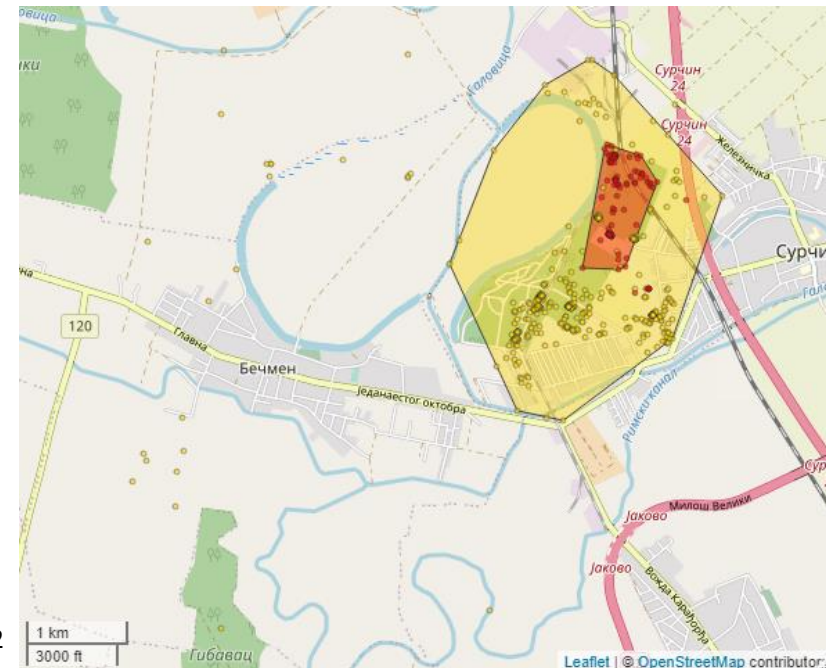
Jackal	MPC 95% spring (km ²)	MPC 95% summer (km ²)	MPC 95% autumn (km ²)	MPC 95% winter (km ²)
M1 Bane	19.50			91.18
M2 Despot	17.17	2.37	26.45	10.96
M3 Djuka	7.77	8.89	8.47	
F1 Doksa	6.85	6.57		
M4 Ilija	20.75	18.01		30.21
F2 Joka	19.52	7.32	10.53	
F3 Mara			0.35	
F4 Milica	5.03	6.36	0.62	2.83
F5 Neda		1.05	1.63	1.61
M5 Nidza	2.10	2.15	1.21	2.25
M6 Peca	3.49			12.64
F6 Sneska	9.00			2.81
M7 Steva	9.95	12.02	3.28	7.79
M7 Zoka	1.40	2.41	5.51	0.62
Average	10.21	6.71	6.45	16.29
Average Males	11.53	8.69	9.85	25.84
Average Females	8.36	4.74	3.73	1.97



Seasonal differences of home ranges



Spring larger
M2 Despot – 17.17 km² vs 2.37 km²

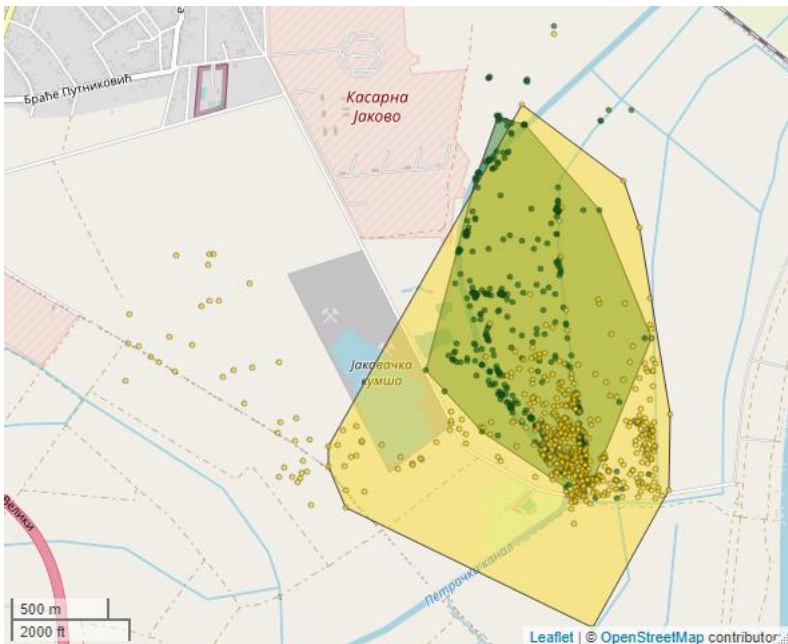


Summer larger
F4 Milica – 6.36 km² vs 0.62 km²

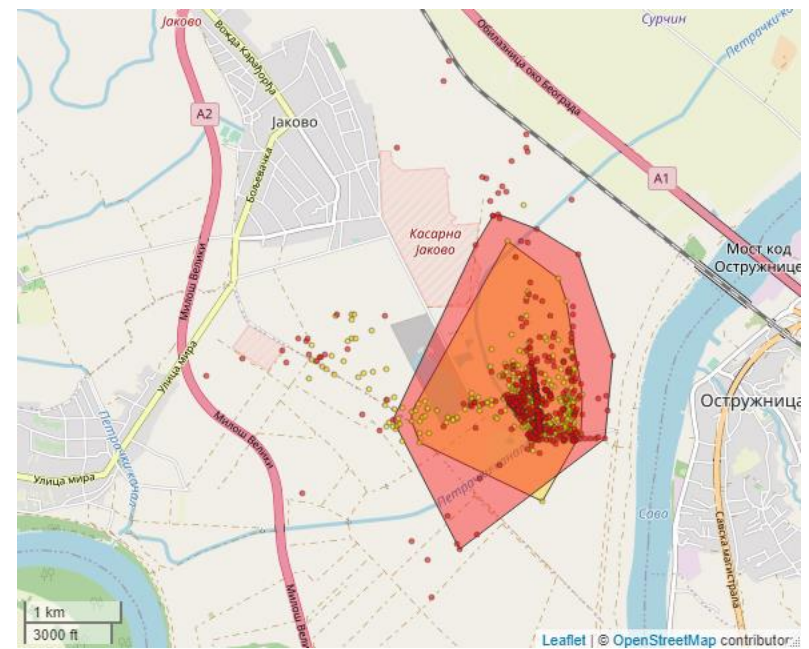


Spring vs summer

Summer vs autumn

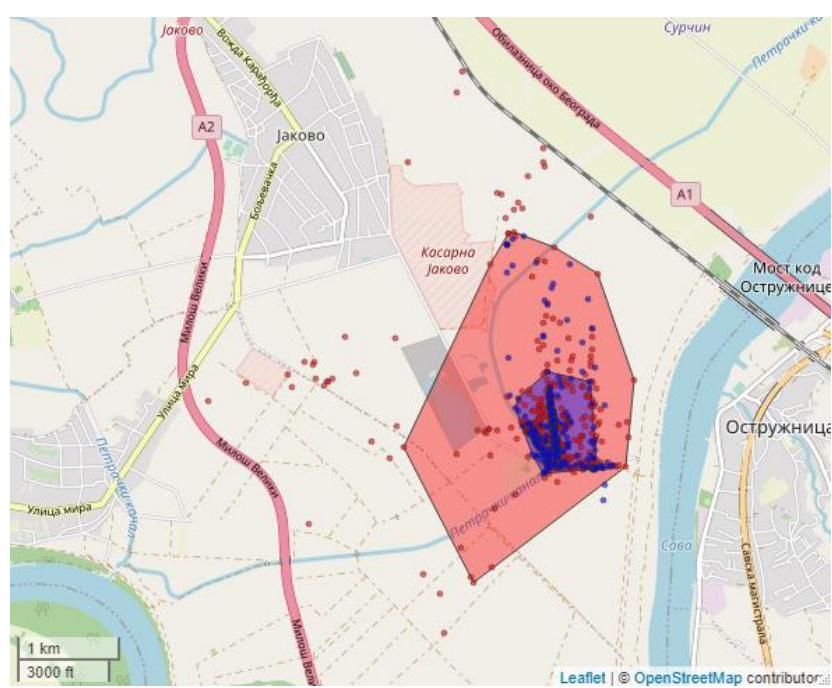


Summer larger
F7 Zoka 2.41 km² vs 1.4 km²



Autumn larger
F7 Zoka 5.51 km² vs 2.41 km²



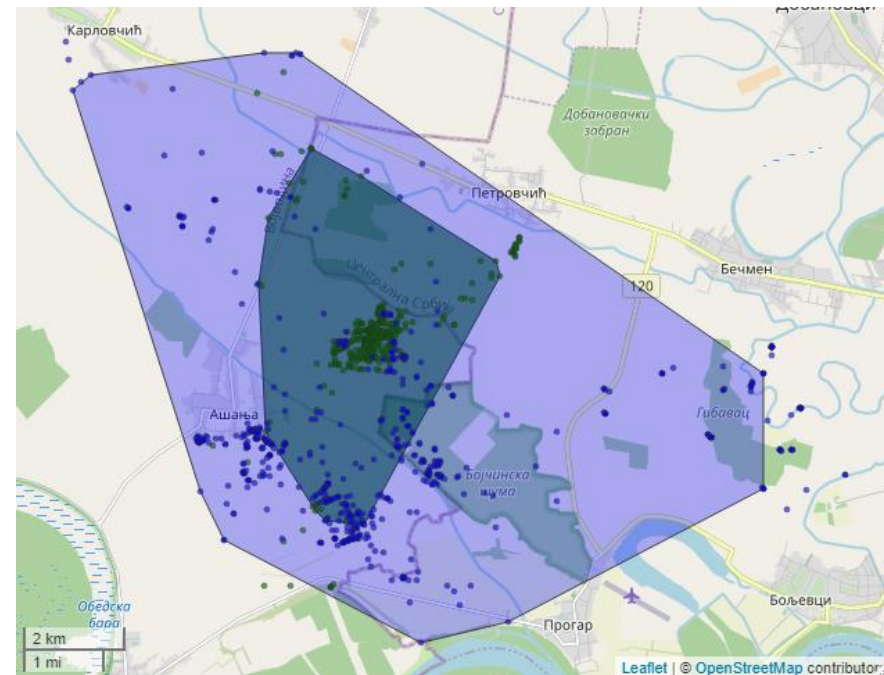


Seasonal dynamics of home ranges

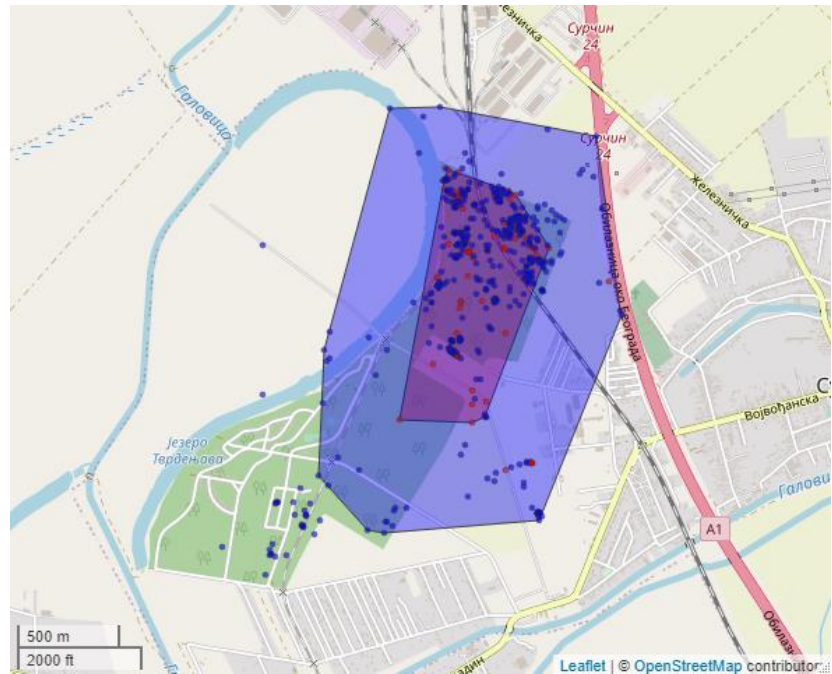
Autumn larger
 F7 Zoka - 5.51 km² vs 0.62 km²



Winter larger
 Bane M1 – 91.18 km² vs 19.50 km²



Autumn vs winter

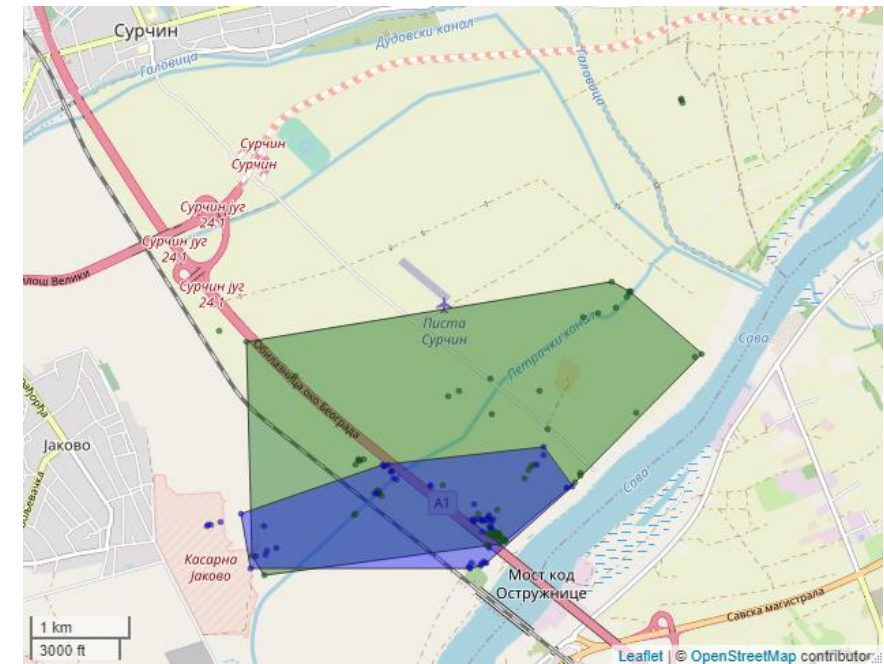


Winter larger
 F4 Milica – 2.83 km² vs 0.62 km²



Spring larger
 F6 Sneska – 9.01 km² vs 2.81 km²

Winter vs spring



Seasonal dynamics of home ranges

Spring larger

F4 Milica – 5.03 km² vs 0.62 km²



Winter larger

M2 Despot – 10.96 km² vs 2.37 km²



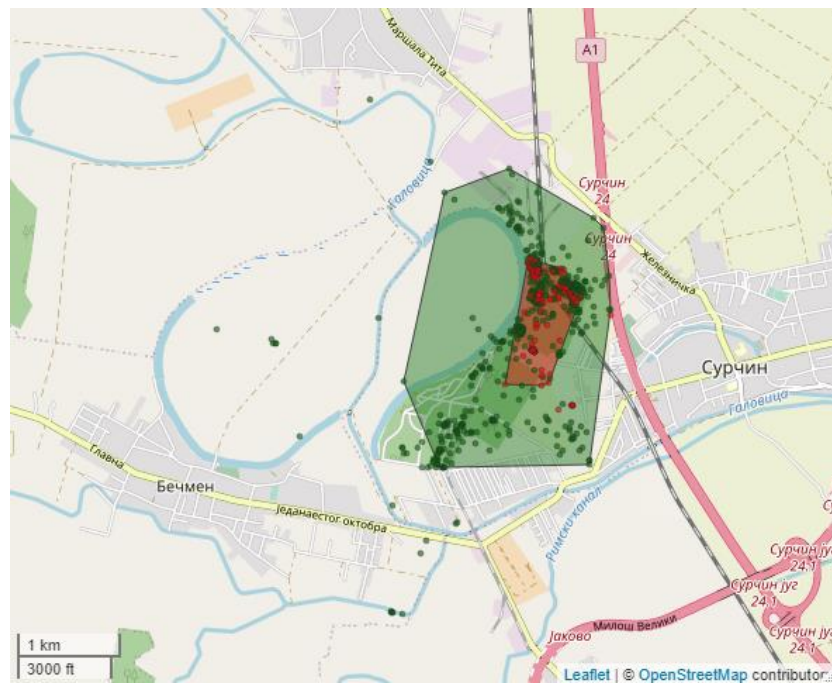
Autumn larger

F7 Zoka – 5.51 km² vs 1.4 km²

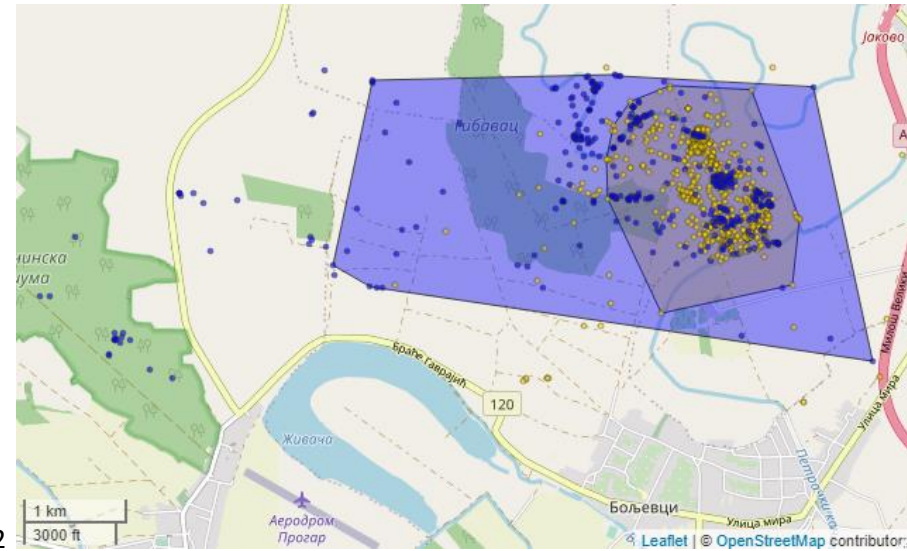


Summer larger

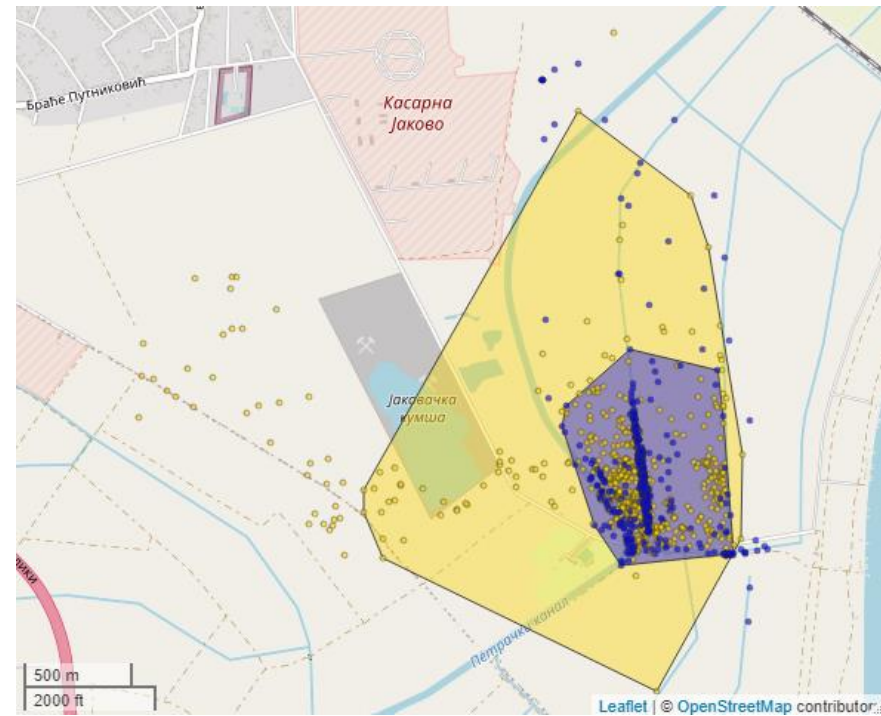
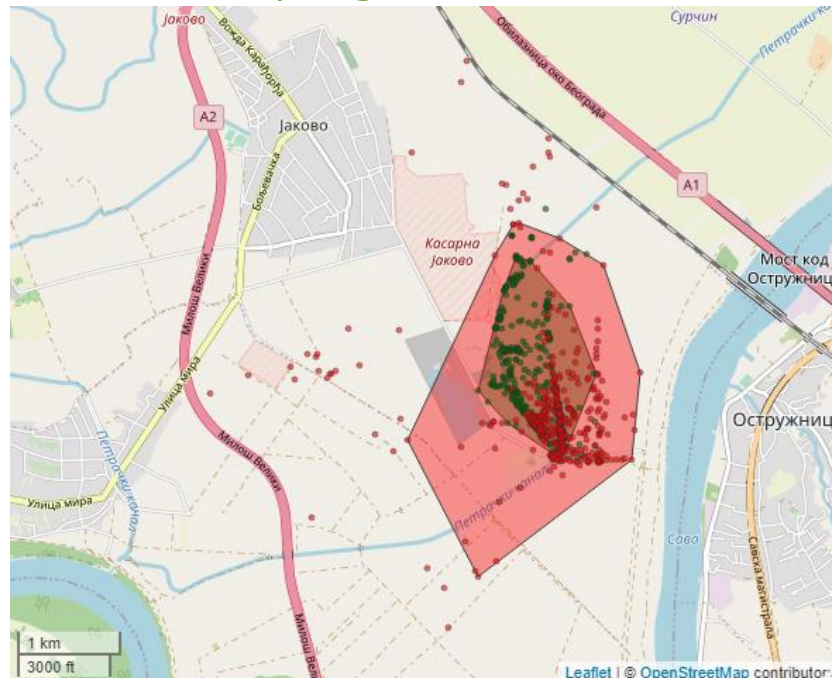
F7 Zoka – 2.41 km² vs 0.62 km²



Spring vs autumn

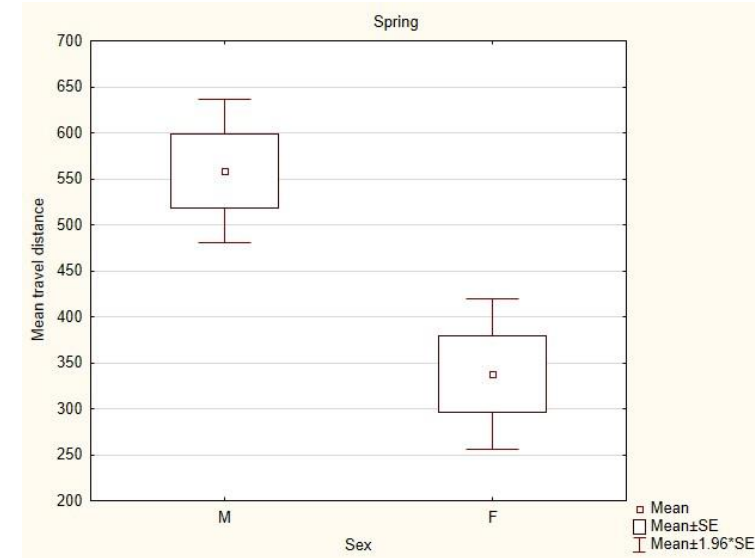


Summer vs winter

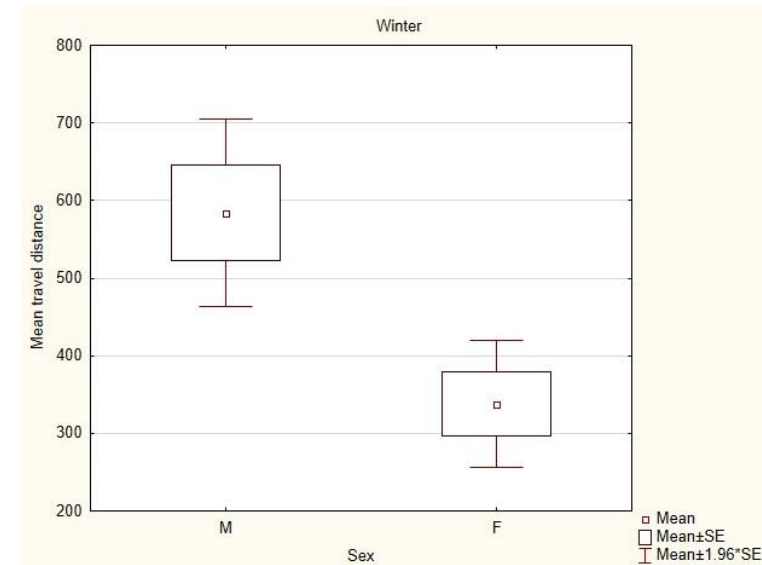


Seasonal dynamics of movement distances

Jackal	Mean travel distance in spring (m)	Mean travel distance in summer (m)	Mean travel distance in autumn (m)	Mean travel distance in winter (m)
M1 Bane	715			867
M2 Despot	768	483	456	544
M3 Djuka	466	725	810	
F1 Doksa	365	779		
M4 Ilija	483	546		483
F2 Joka	234	307	550	
F3 Mara			201	
F4 Milica	449	468	241	367
F5 Neda		351	423	433
M5 Nidza	480	376	397	510
M6 Peca	500			463
F6 Sneska	756			315
M7 Steva	653	780	312	636
M7 Zoka	426	451	483	237
Average	524	527	430	485
Average Males	581	582	494	584
Average Females	446	471	380	338




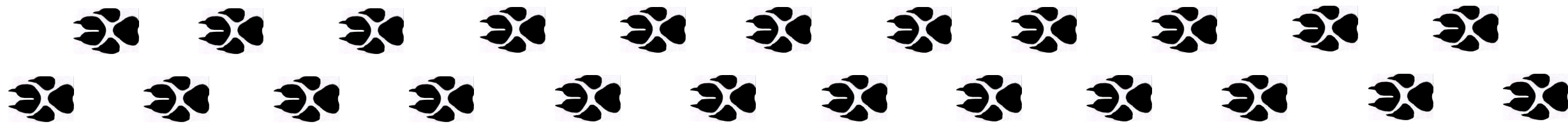
Significant differences for seasonal movement distances between sexes were found for spring ($t=3.70, p < 0.05$) and winter ($t=2.93, p < 0.05$) when males travelled more than females.



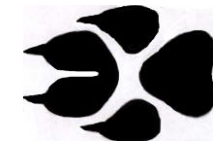
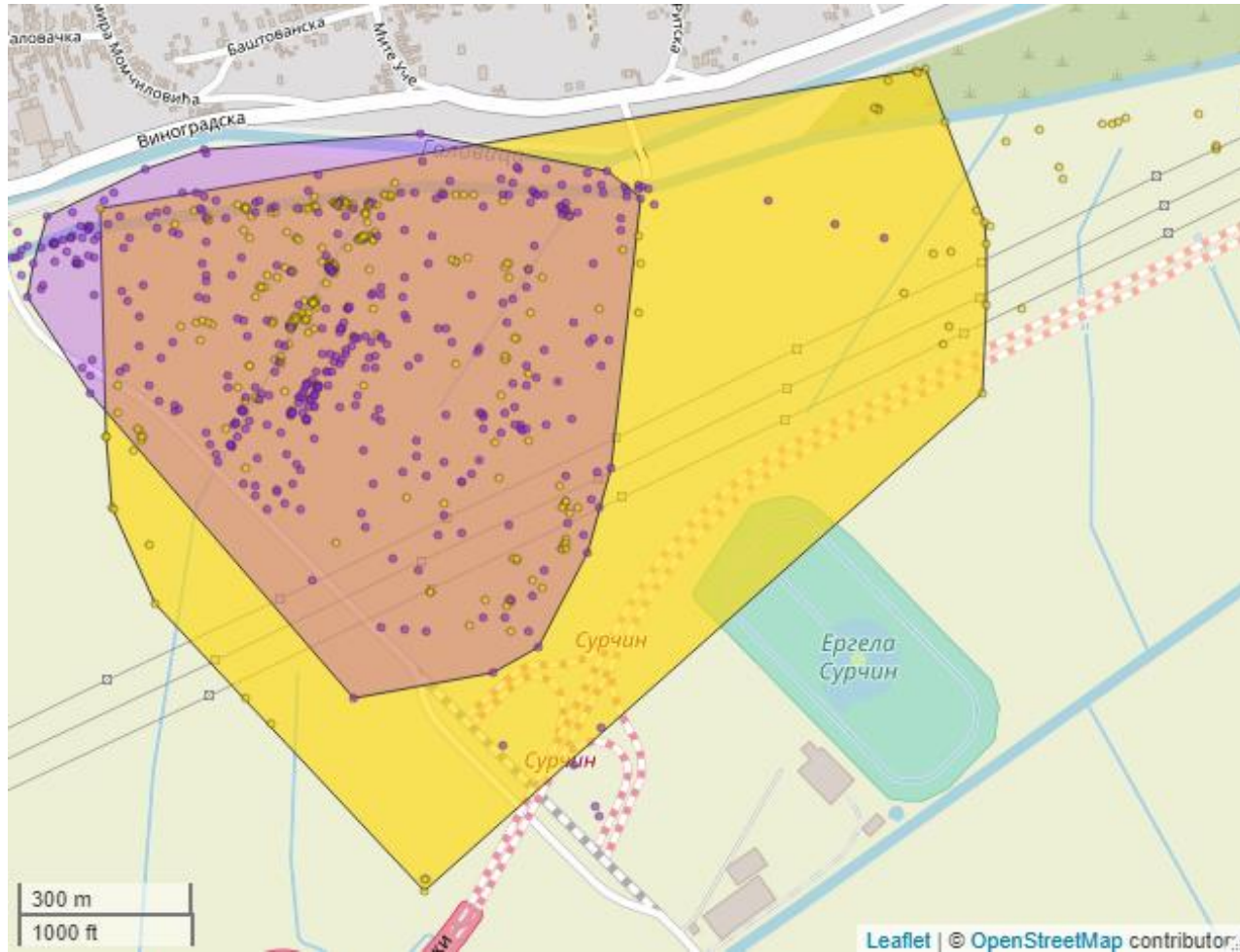
Seasonal and daytime dynamics of home ranges

	Daytime Home range (km ²)								Nighttime Home range (km ²)							
	Spring	ID	Summer	ID	Autumn	ID	Winter	ID	Spring	ID	Summer	ID	Autumn	ID	Winter	ID
Largest	14.13	Joka F2	11.56	Ilija M4	12.26	Despot M2	54.69	Bane M1	22.71	Bane M1	19.36	Ilija M4	24.24	Despot M2	90.46	Bane M1
Smallest	0.96	Milica F4	0.45	Zoka F7	0.11	Mara F3	0.12	Neda	1.15	Zoka F7	1.03	Neda F5	0.36	Mara F3	0.71	Zoka F7
Average	4.55		4.49		2.73	8.84		9.97		7.17		6.27	15.95			
Average male	4.38		5.99		3.81	14.45		12.01		9.4		9.16		25.52		
Average female	4.8		2.99		1.86	0.42		7.12		4.94		3.97		1.61		

 The daytime home ranges were on smaller compared to nighttime home ranges, ranging from 0.92 to 0.05 times in spring, 0.99 to 0.11 in summer, 0.83* to 0.03 in autumn, 0.8 to 0.09 in winter.



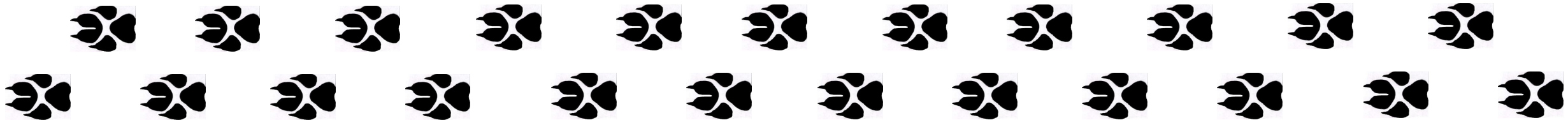
Seasonal and daytime dynamics of home ranges



M5 Nidza


Night – 0.66 km²

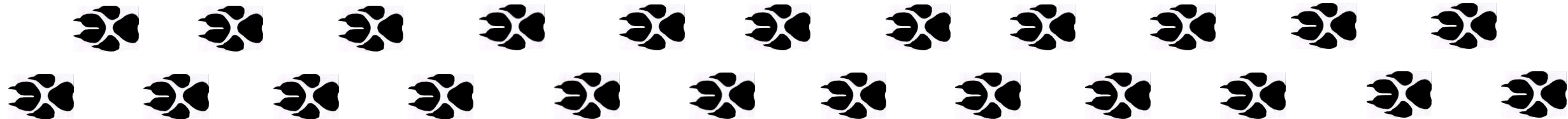
Day – 1.38 km²



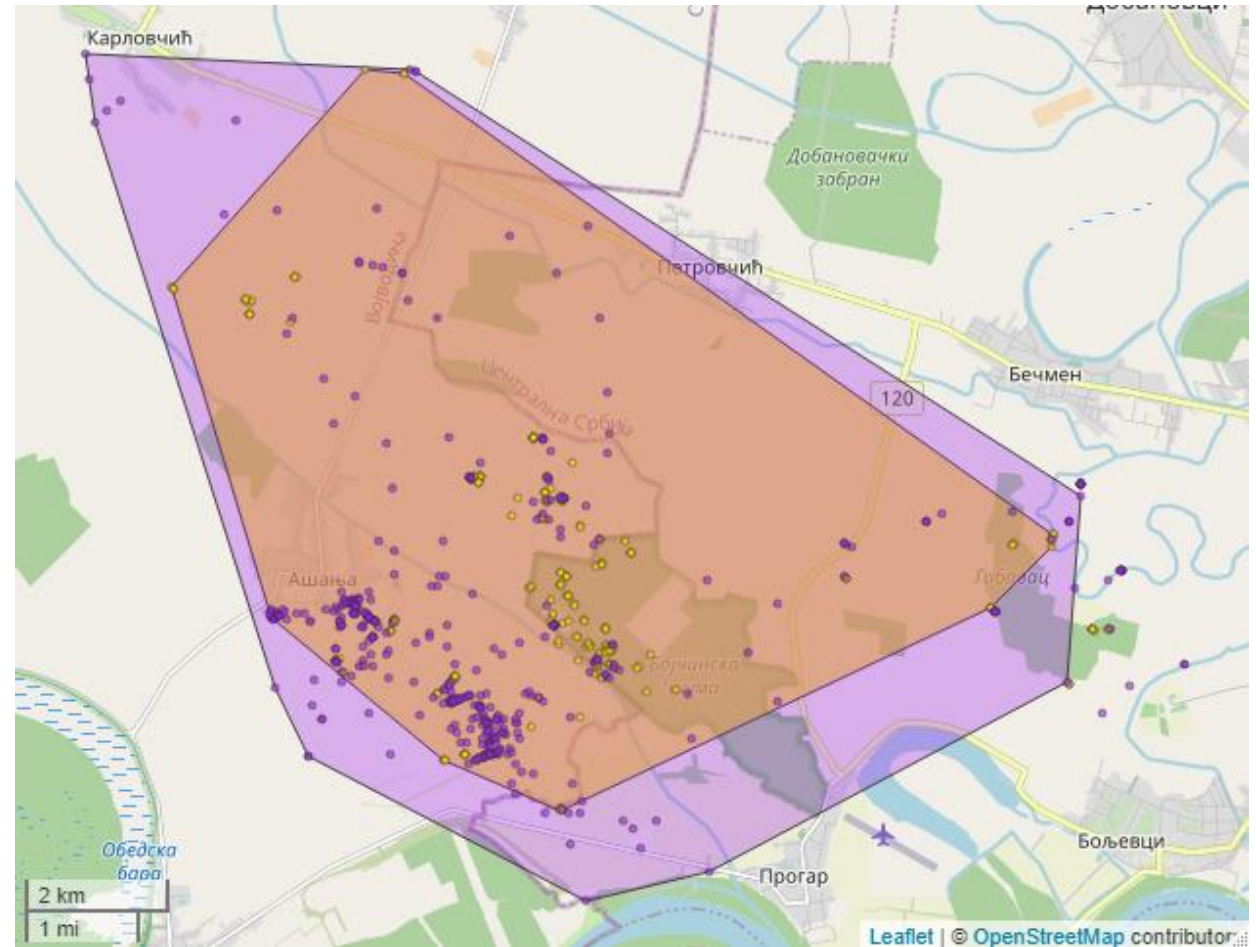
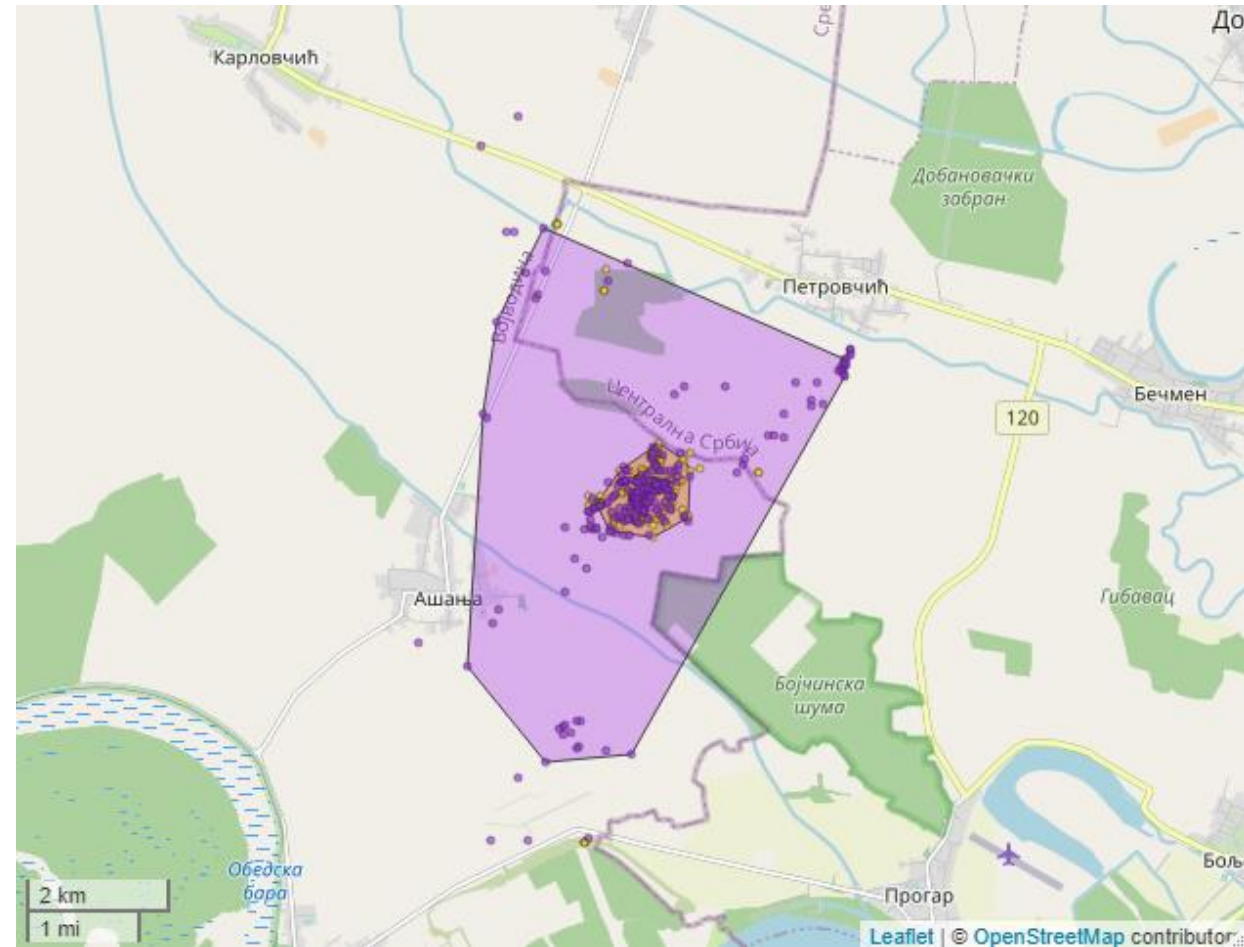
Seasonal and daytime dynamics of home ranges

	Daytime Home range (km ²)								Nighttime Home range (km ²)							
	Spring	ID	Summer	ID	Autumn	ID	Winter	ID	Spring	ID	Summer	ID	Autumn	ID	Winter	ID
Largest	14.13	Joka F2	11.56	Ilija M4	12.26	Despot M2	54.69	Bane M1	22.71	Bane M1	19.36	Ilija M4	24.24	Despot M2	90.46	Bane M1
Smallest	0.96	Milica F4	0.45	Zoka F7	0.11	Mara F3	0.12	Neda	1.15	Zoka F7	1.03	Neda F5	0.36	Mara F3	0.71	Zoka F7
Average	4.55		4.49		2.73		8.84		9.97		7.17		6.27		15.95	
Average male	4.38		5.99		3.81		14.45		12.01		9.4		9.16		25.52	
Average female	4.8		2.99		1.86		0.42		7.12		4.94		3.97		1.61	

 The daytime home ranges were on smaller compared to nighttime home ranges, ranging from 0.92 to 0.05 times in spring, 0.99 to 0.11 in summer, 0.83* to 0.03 in autumn, 0.8 to 0.09 in winter.



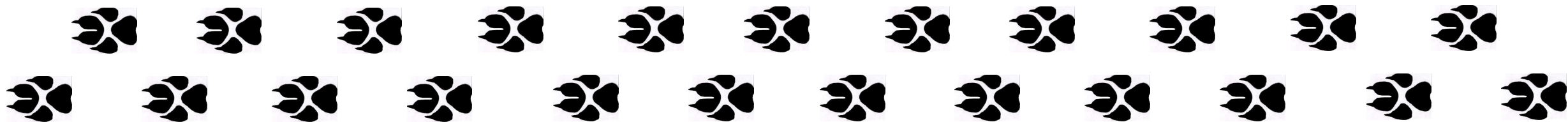
Seasonal and daytime dynamics of home ranges



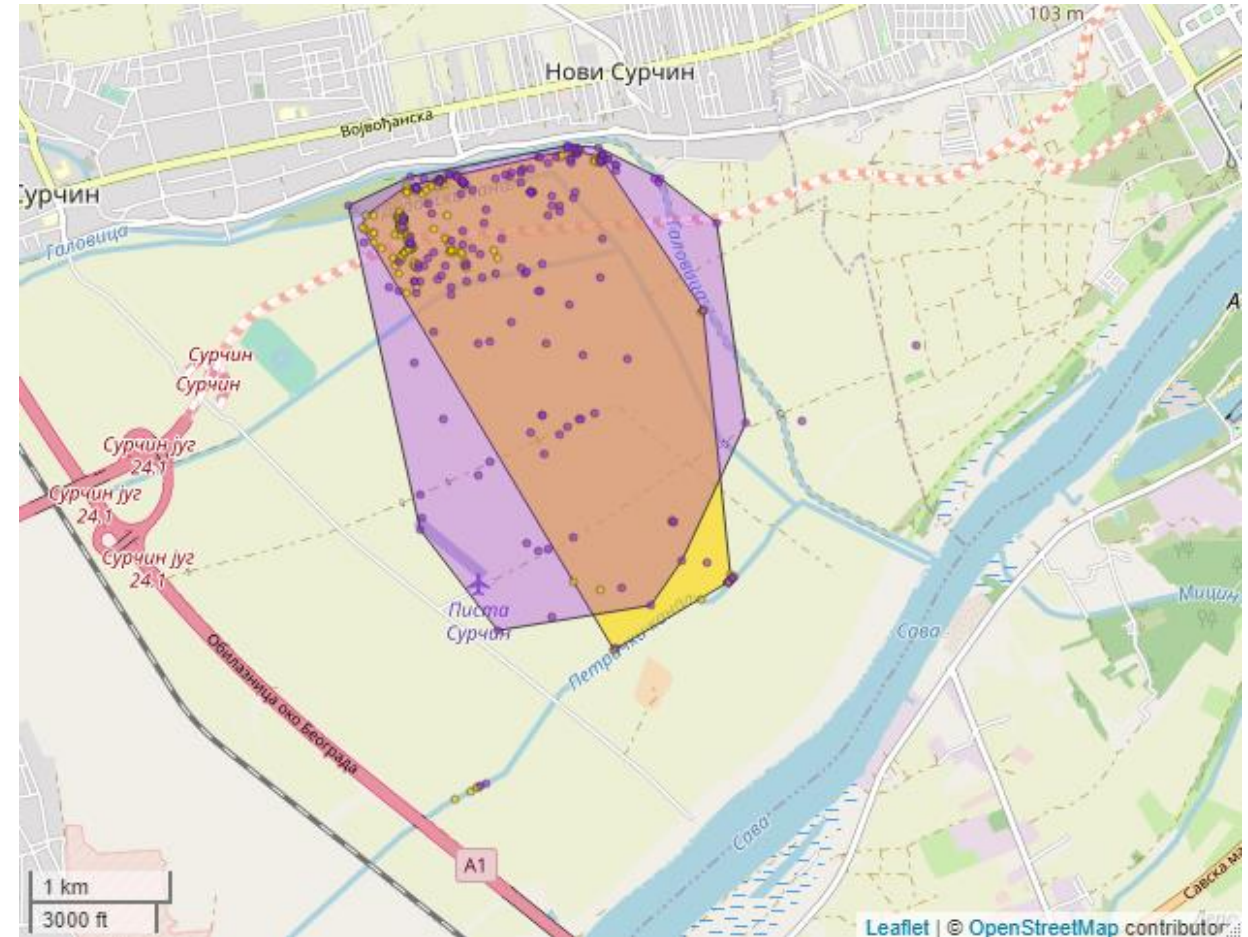
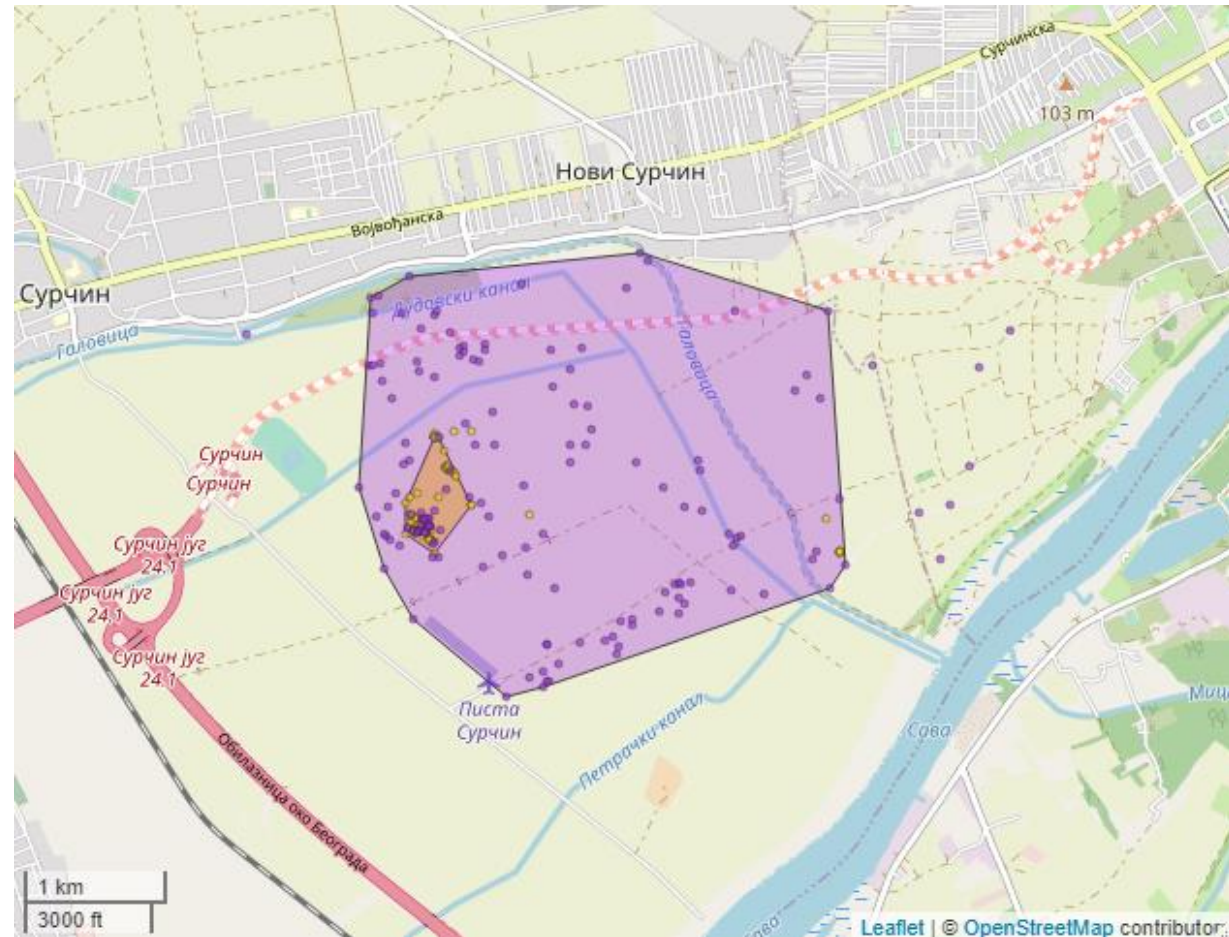
Spring: daytime – 1.15 km², nighttime – 22.71 km²

M1 Bane

Winter: daytime – 54.69 km², nighttime – 90.46 km²

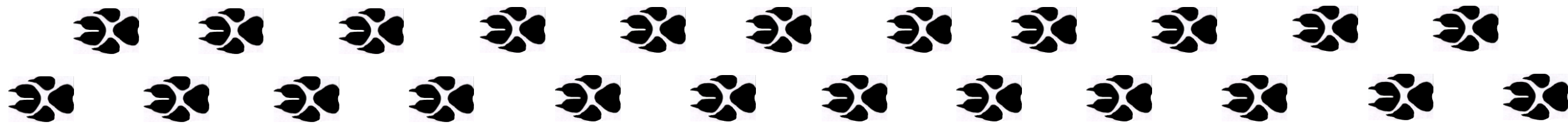


Seasonal and daytime dynamics of home ranges

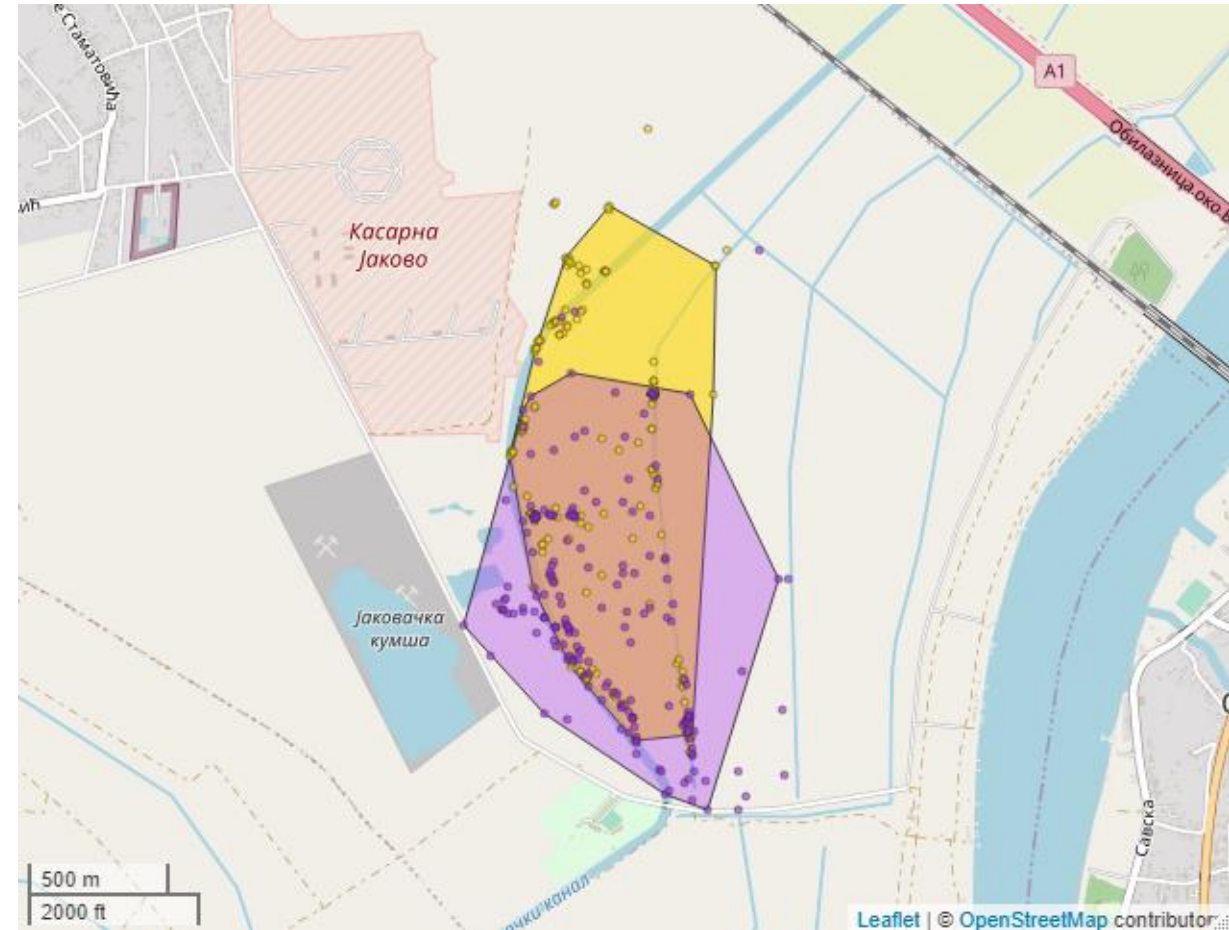
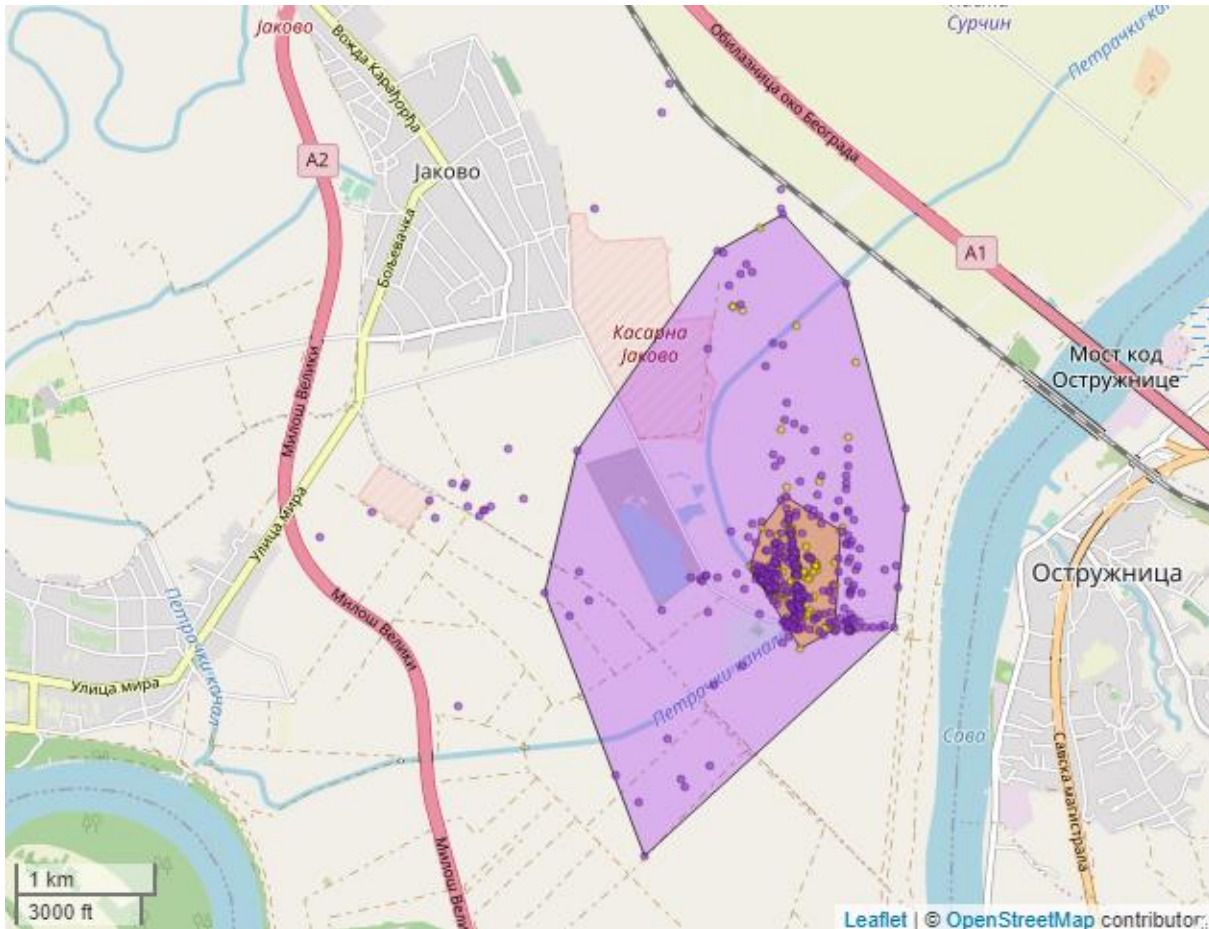


Autumn: daytime – 0.22 km², nighttime – 8.44 km²

M3 Djuka Spring: daytime – 5.01 km², nighttime – 7.29 km²



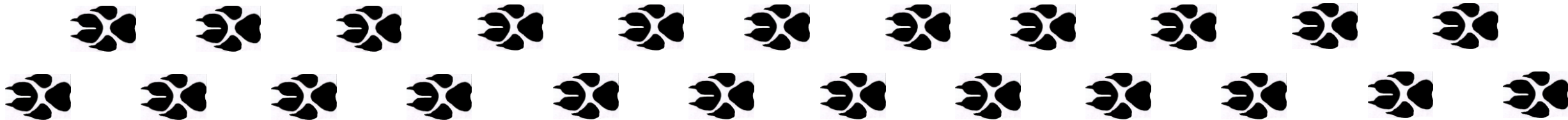
Seasonal and daytime dynamics of home ranges



Autumn: daytime – 0.36 km², nighttime – 7.28 km²


F7 Zoka


Spring: daytime – 1.05 km², nighttime – 1.15 km²

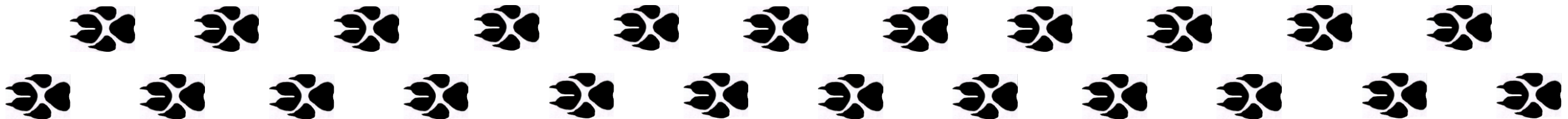


Seasonal and daytime dynamics of movement distances

	Daytime movement distance means (3h)								Nighttime movement distance means (3h)							
	Spring	ID	Summer	ID	Autumn	ID	Winter	ID	Spring	ID	Summer	ID	Autumn	ID	Winter	ID
Longest	557	F6 Sneska	563	M7 Steva	377	F2 Joka	621	M1 Bane	1305	M4 Ilija	1223	M3 Djuka	1527	M3 Djuka	1012	M1 Bane
Shortest	211	M2 Djuka	230	F4 Milica	125	F3 Mara	70	M4 Ilija	283	F2 Joka	305	F2 Joka	197	F4 Milica	304	M7 Zoka
Average	319		340		232		300		838		834		626		592	
Males	333		355		220		364		1004		962		772		714	
Females	298		325		242		204		607		705		509		408	

 The daytime average movement distances were mostly shorter compared to nighttime average movement distances, ranging from 0.52 to 0.24 shorter in spring, 1.01 (F2 Joka: daytime 309 m vs nighttime 305 m) to 0.22 in summer, 1.54* (M5 Nidza: daytime 508 m to nighttime 266 m) to 0.1 in autumn, and 0.94 to 0.1 in winter.

 For males the largest average difference in movement distances was in spring – 0.34 times shorter, and the smallest was 0.52 during winter, conversely, for females the biggest difference in movement distances was in winter – 0.49 times shorter, and the smallest in 0.63 during spring.



Thank you for your time



Collaring of my namesake Ilija

