

Supplementary data: The impact of urbanization on coyote movement rate and its potential implications for seed dispersal

Table S1 Summary of coyote individuals included in the study, demographics, and number of days with tracking data recorded per landscape type and social status.
Abbreviations: F = female; M = male; A = adult; J = juvenile; Y = yearling.

	ANIMAL ID	SEX	AGE	LANDSCAPE	SOCIAL STATUS	N DAYS
1	MISS001	M	A	Urban	Resident	237
					Transient	73
2	MISS002	F	A	Urban	Resident	216
3	MISS003	F	J	Urban	Resident	362
4	MISS004	F	A	Urban	Resident	384
5	MISS007	F	A	Urban	Resident	167
6	MISS011	M	J	Urban	Resident	171
					Transient	70
7	MISS013	F	A	Urban	Resident	357
8	MISS014	F	Y	Rural	Resident	5
					Transient	3
				Urban	Resident	184
					Transient	76
9	MISS018	M	J	Rural	Disperser	117
				Urban	Disperser	167
10	MISS020	M	A	Urban	Resident	291
11	MISS021	M	J	Urban	Transient	12
12	MISS022	M	A	Urban	Transient	348
13	PEC001	M	A	Rural	Resident	171
14	PEC004	M	Y	Rural	Transient	90
15	PEC005	M	Y	Rural	Transient	174
16	PEC006	F	A	Rural	Resident	37
17	PEC007	M	A	Rural	Transient	193
18	PEC009	M	A	Rural	Resident	153
					Transient	60
19	PEC011	F	Y	Rural	Transient	214
20	PEC012	M	Y	Rural	Transient	305
21	PEC014	M	Y	Rural	Resident	381
22	PEC015	F	A	Rural	Resident	325
23	PEC027	M	A	Rural	Resident	333
24	PEC028	M	Y	Rural	Transient	80
25	PEC029	M	A	Rural	Resident	43
					Transient	53
26	PEC030	M	J	Rural	Resident	148
27	PEC032	F	A	Rural	Resident	275
28	PEC035	F	A	Rural	Resident	86
29	PEC040	M	A	Rural	Resident	61
30	PEC042	F	Y	Rural	Transient	283
31	PEC043	M	A	Rural	Resident	184
32	PEC044	F	Y	Rural	Transient	93
33	PEC047	F	A	Rural	Resident	201
					Transient	155
34	PEC049	M	A	Rural	Resident	67
					Transient	284
35	PEC052	M	Y	Rural	Resident	86
36	PEC053	F	A	Rural	Transient	138
37	PEC054	F	Y	Rural	Transient	267
38	PEC059	M	Y	Rural	Resident	163

					Transient	38
39	PECo66	M	A	Rural	Resident	178
40	PECo74	F	A	Rural	Resident	358
41	PECo81	F	Y	Rural	Transient	223
42	PECo83	M	Y	Rural	Resident	363
43	PECo86	M	A	Rural	Transient	115
44	PECo87	F	A	Rural	Transient	142
45	PECo88	M	A	Rural	Resident	301
46	PECo89	F	A	Rural	Resident	58
47	PECo90	M	A	Rural	Resident	57
					Transient	70
48	PECo91	M	J	Rural	Resident	145
49	PECo92	M	A	Rural	Resident	317
50	PECo93	M	J	Rural	Resident	9
					Transient	57
51	PECo94	M	J	Rural	Resident	80
					Transient	12
52	PECo95	M	A	Rural	Transient	114
53	PEC101	M	A	Rural	Resident	209
54	PEC103	M	A	Rural	Resident	249
55	PEC104	F	A	Rural	Transient	133
56	PEC105	F	A	Rural	Transient	58
57	PEC106	M	A	Rural	Resident	218
58	PEC107	M	Y	Rural	Resident	303
59	PEC108	F	A	Rural	Transient	224
60	PEC112	F	A	Rural	Resident	92
					Transient	39
61	PEC113	F	Y	Rural	Resident	317
62	PEC114	F	Y	Rural	Transient	202
63	PEC116	F	Y	Rural	Transient	265
64	PEC120	M	A	Rural	Resident	38
					Transient	172
65	PEC122	F	A	Rural	Transient	138
66	PEC129	M	Y	Rural	Resident	93
					Transient	78
67	PEC131	M	A	Rural	Resident	234
68	PEC135	F	Y	Rural	Transient	92
69	PEC137	M	A	Rural	Resident	157
					Transient	55
70	PEC141	F	A	Rural	Resident	71
					Transient	49
71	URBAN001	M	A	Urban	Resident	324
72	URBAN002	F	A	Urban	Resident	331
73	URBAN005	M	A	Rural	Transient	18
				Urban	Transient	216
74	URBAN006	F	A	Urban	Resident	4
75	URBAN007	F	Y	Urban	Transient	24
76	URBAN008	F	A	Rural	Resident	562
					Transient	3
				Urban	Transient	24
77	URBAN009	M	A	Rural	Resident	18
				Urban	Resident	697
				Urban	Transient	9
78	URBAN010	F	A	Rural	Transient	1
				Urban	Resident	213
					Transient	1
79	URBAN011	F	A	Urban	Resident	363
80	URBAN012	M	Y	Urban	Resident	88
81	URBAN013	F	Y	Rural	Disperser	59

				Urban	Disperser	58
82	URBAN014	M	A	Urban	Resident	668
83	URBAN015	M	A	Rural	Resident	133
					Transient	114
				Urban	Transient	159
84	URBAN016	F	A	Urban	Transient	442
85	URBAN017	M	A	Urban	Resident	126
86	URBAN018	M	A	Rural	Disperser	110
				Urban	Disperser	121
87	URBAN019	F	A	Rural	Transient	18
				Urban	Resident	305
					Transient	49
88	URBAN020	F	A	Urban	Transient	362
89	URBAN021	M	A	Rural	Disperser	17
				Urban	Disperser	19
90	URBAN022	M	A	Rural	Transient	1
				Urban	Transient	57
91	URBAN023	M	J	Urban	Resident	185
92	URBAN024	M	J	Rural	Resident	15
					Transient	1
				Urban	Resident	184
					Transient	39
93	URBAN025	M	J	Rural	Resident	173
					Transient	88
				Urban	Resident	20
					Transient	47
94	URBAN026	M	A	Urban	Resident	164

Table S2.1 GLMM model output of the effect urbanization has on coyote net displacement when considering the (a) urban-only model (b) social status model, (c) biological season model and (d) climate season model.

a. Urban-only model

GLMM: Retention time * Landscape type		
Predictors	Estimates	Conf. Int (95%)
0-6hrs:Rural	936.40 ***	857.32 – 1022.78
6-24hrs:Rural	1808.42 ***	1655.75 – 1975.18
24-48hrs:Rural	2354.69 ***	2155.89 – 2571.83
48-72hrs:Rural	2670.17 ***	2444.71 – 2916.43
0-6hrs:Urban	0.71 ***	0.69 – 0.74
6-24hrs:Urban	0.70 ***	0.68 – 0.72
24-48hrs:Urban	0.66 ***	0.64 – 0.68
48-72hrs:Urban	0.62 ***	0.60 – 0.64
Random Effects		
σ^2	0.70	
τ_{00} Id_f	0.14	
ICC	0.16	
N Id_f	94	
Observations	160606	
Marginal R ² / Conditional R ²	0.178 / 0.313	

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

b. Social status model

Predictors	0-6hrs		6-24hrs		24-48hrs		48-72hrs	
	Estimates	Conf. Int (95%)	Estimates	Conf. Int (95%)	Estimates	Conf. Int (95%)	Estimates	Conf. Int (95%)
Resident:Rural (Intercept)	707.91 ***	652.94 – 767.51	1181.35 ***	1081.73 – 1290.14	1307.30 ***	1188.67 – 1437.77	1375.28 ***	1250.21 – 1512.86
Transient:Rural	1.34 ***	1.27 – 1.41	1.99 ***	1.91 – 2.08	2.76 ***	2.65 – 2.87	3.18 ***	3.05 – 3.32
Disperser:Rural	2.30 ***	1.61 – 3.28	3.98 ***	2.66 – 5.96	6.97 ***	4.47 – 10.87	9.48 ***	6.15 – 14.60
Resident:Urban	0.91	0.82 – 1.00	0.97	0.89 – 1.05	1.00	0.92 – 1.09	0.93	0.85 – 1.02
Transient:Urban	0.83 ***	0.76 – 0.91	0.81 ***	0.76 – 0.87	0.85 ***	0.79 – 0.91	0.85 ***	0.79 – 0.92
Disperser:Urban	0.41 ***	0.37 – 0.45	0.37 ***	0.34 – 0.40	0.34 ***	0.32 – 0.37	0.31 ***	0.29 – 0.34
Random Effects								
σ^2	0.67		0.52		0.50		0.52	
τ_{00}	0.08 Id_f		0.08 Id_f		0.10 Id_f		0.10 Id_f	
ICC	0.11		0.14		0.16		0.16	
N	94 Id_f		94 Id_f		94 Id_f		94 Id_f	
Observations	38956		40816		40610		40224	
Marginal R ² / Conditional R ²	0.038 / 0.141		0.159 / 0.275		0.290 / 0.403		0.361 / 0.462	

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

14 c. Biological season model

<i>Predictors</i>	0-6hrs		6-24hrs		24-48hrs		48-72hrs	
	<i>Estimates</i>	<i>Conf. Int (95%)</i>	<i>Estimates</i>	<i>Conf. Int (95%)</i>	<i>Estimates</i>	<i>Conf. Int (95%)</i>	<i>Estimates</i>	<i>Conf. Int (95%)</i>
Breeding:Rural (Intercept)	963.97 ***	896.41 – 1036.62	2023.47 ***	1855.05 – 2207.19	2670.81 ***	2391.62 – 2982.61	3000.35 ***	2650.33 – 3396.59
Dispersal:Rural	0.91 ***	0.89 – 0.94	0.90 ***	0.88 – 0.92	0.88 ***	0.86 – 0.90	0.88 ***	0.86 – 0.90
Pup-rearing:Rural	0.84 ***	0.81 – 0.87	0.74 ***	0.72 – 0.76	0.72 ***	0.70 – 0.74	0.72 ***	0.70 – 0.74
Breeding:Urban	0.62 ***	0.58 – 0.67	0.61 ***	0.58 – 0.64	0.62 ***	0.59 – 0.66	0.61 ***	0.57 – 0.64
Dispersal:Urban	0.69 ***	0.65 – 0.74	0.71 ***	0.67 – 0.75	0.74 ***	0.70 – 0.78	0.71 ***	0.67 – 0.76
Pup-rearing:Urban	0.71 ***	0.67 – 0.76	0.73 ***	0.69 – 0.77	0.76 ***	0.72 – 0.80	0.76 ***	0.72 – 0.81
Random Effects								
σ^2	0.69		0.56		0.60		0.64	
τ_{00}	0.07 Id_f		0.10 Id_f		0.17 Id_f		0.23 Id_f	
ICC	0.10		0.15		0.22		0.27	
N	94 Id_f		94 Id_f		94 Id_f		94 Id_f	
Observations	38956		40816		40610		40224	
Marginal R ² / Conditional R ²	0.048 / 0.140		0.065 / 0.203		0.052 / 0.262		0.049 / 0.302	

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

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16 d. Climate season model

<i>Predictors</i>	0-6hrs		6-24hrs		24-48hrs		48-72hrs	
	<i>Estimates</i>	<i>Conf. Int (95%)</i>	<i>Estimates</i>	<i>Conf. Int (95%)</i>	<i>Estimates</i>	<i>Conf. Int (95%)</i>	<i>Estimates</i>	<i>Conf. Int (95%)</i>
Autumn:Rural (Intercept)	891.67 ***	829.67 – 958.29	1889.29 ***	1731.70 – 2061.23	2454.51 ***	2197.79 – 2741.22	2764.65 ***	2441.79 – 3130.20
Spring:Rural	0.95 *	0.92 – 0.99	0.86 ***	0.83 – 0.89	0.86 ***	0.84 – 0.89	0.86 ***	0.83 – 0.88
Summer:Rural	0.90 ***	0.87 – 0.92	0.78 ***	0.76 – 0.80	0.75 ***	0.74 – 0.77	0.74 ***	0.73 – 0.76
Winter:Rural	1.11 ***	1.08 – 1.14	1.10 ***	1.08 – 1.13	1.12 ***	1.09 – 1.15	1.12 ***	1.09 – 1.15
Autumn:Urban	0.69 ***	0.64 – 0.73	0.70 ***	0.66 – 0.74	0.72 ***	0.68 – 0.76	0.69 ***	0.65 – 0.73
Spring:Urban	0.69 ***	0.64 – 0.74	0.70 ***	0.66 – 0.74	0.72 ***	0.68 – 0.76	0.72 ***	0.68 – 0.77
Summer:Urban	0.74 ***	0.69 – 0.80	0.79 ***	0.75 – 0.84	0.83 ***	0.78 – 0.88	0.82 ***	0.77 – 0.87
Winter:Urban	0.61 ***	0.57 – 0.65	0.59 ***	0.56 – 0.62	0.61 ***	0.57 – 0.64	0.58 ***	0.55 – 0.62
Random Effects								
σ^2	0.69		0.56		0.59		0.64	
τ_{00}	0.08 Id_f		0.10 Id_f		0.17 Id_f		0.23 Id_f	
ICC	0.10		0.15		0.22		0.27	
N	94 Id_f		94 Id_f		94 Id_f		94 Id_f	
Observations	38956		40816		40610		40224	
Marginal R ² / Conditional R ²	0.048 / 0.141		0.066 / 0.205		0.054 / 0.265		0.052 / 0.305	

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

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Table S2.2. Akaike Information Criterion (AIC) values for models in Table S2a. Parameters include the number of estimated parameters for each model (K), AIC with correction for small sample sizes (AICc), the Akaike weights (i.e. “model probabilities”) (AICcWt), the cumulative Akaike weights (Cum.Wt), and the log-likelihood (LL) of each model, for each seed retention timeframe (a-d).

a. 0-6 hrs retention timeframe

	K	AICc	Delta_AICc	AICcWt	Cum.Wt	LL
Social status model	8	594959	0	1	1	-297471.5
Climate season model	10	595135.2	176.16	0	1	-297557.6
Biological season model	8	595170.5	211.45	0	1	-297577.2

b. 6-24 hrs retention timeframe

	K	AICc	Delta_AICc	AICcWt	Cum.Wt	LL
Social status model	8	670013.9	0	1	1	-334999
Climate season model	10	671049.1	1035.2	0	1	-335514.6
Biological season model	8	671187.8	1173.9	0	1	-335585.9

c. 24-48 hrs retention timeframe

	K	AICc	Delta_AICc	AICcWt	Cum.Wt	LL
Social status model	8	684525.7	0	1	1	-342254.8
Climate season model	10	687202.9	2677.2	0	1	-343591.5
Biological season model	8	687405.1	2879.4	0	1	-343694.5

d. 48-72 hrs retention timeframe

	K	AICc	Delta_AICc	AICcWt	Cum.Wt	LL
Social status model	8	684559.4	0	1	1	-342271.7
Climate season model	10	688268.8	3709.4	0	1	-344124.4
Biological season model	8	688501	3941.6	0	1	-344242.5

Table S3 Estimated seed dispersal distance statistics from coyote net displacement (quantiles (5%, 50% [median], 95%); overall mean across individuals with standard error (SE) and 95% confidence interval range (95 % CI); number of individuals per group (N_{ind}), number of total days for which seed dispersal estimated (N_{days}), and number of steps (N_{SDE}), for coyotes in urban and rural landscapes, across retention times, considering biological season (a), and climate season (b).

a. Biological seasons

Breeding										
	Retention time	5% (m)	Median (m)	95% (m)	Mean (m)	SE (m)	95% CI (m)	N_{ind}	N_{days}	N_{SDE}
URBAN	0-6hrs	121	551	1559	686	45	91	31	2457	79746
	6-24hrs	207	991	3562	1382	113	230	31	2736	303879
	24-48hrs	268	1201	4683	1900	193	393	31	2729	403001
	48-72hrs	297	1237	4984	2173	268	546	31	2704	401195
RURAL	0-6hrs	221	905	2314	1066	121	242	51	3463	49530
	6-24hrs	446	1663	5630	2082	143	288	49	3470	184986
	24-48hrs	554	1877	9273	3058	308	620	48	3433	243945
	48-72hrs	586	1944	11252	3672	454	914	47	3401	241367

Dispersal										
	Retention time	5% (m)	Median (m)	95% (m)	Mean (m)	SE (m)	95% CI (m)	N_{ind}	N_{days}	N_{SDE}
URBAN	0-6hrs	104	589	1575	682	50	103	30	2473	45335
	6-24hrs	193	1167	3948	1385	148	302	30	2794	162197
	24-48hrs	273	1389	4995	1925	254	521	29	2787	213619
	48-72hrs	269	1395	5094	2076	322	660	30	2762	211226
RURAL	0-6hrs	232	819	1867	965	55	109	62	5972	37754
	6-24hrs	465	1539	4419	2039	179	357	63	5974	144515
	24-48hrs	564	1809	7271	2973	382	763	63	5955	191033
	48-72hrs	619	1877	8882	3580	554	1108	63	5920	188892

Pup-rearing										
	Retention time	5% (m)	Median (m)	95% (m)	Mean (m)	SE (m)	95% CI (m)	N_{ind}	N_{days}	N_{SDE}
URBAN	0-6hrs	89	505	1339	633	62	128	26	2221	46714
	6-24hrs	129	847	3306	1206	114	235	28	2743	165452
	24-48hrs	178	1007	4272	1576	174	358	27	2763	219521
	48-72hrs	232	1025	4761	1711	197	406	27	2726	217920
RURAL	0-6hrs	220	813	1779	797	43	87	48	3086	49600
	6-24hrs	436	1385	3752	1436	90	181	47	3093	174718
	24-48hrs	538	1557	6161	1917	173	348	46	3060	230623
	48-72hrs	580	1620	7790	2216	242	487	46	3032	228601

b. Climate seasons

Autumn										
	Retention time	5% (m)	Median (m)	95% (m)	Mean (m)	SE (m)	95% CI (m)	N_{ind}	N_{days}	$NSDE$
URBAN	0-6hrs	109	574	1573	696	54	111	30	1951	23585
	6-24hrs	201	1135	4055	1424	163	334	30	2164	88452
	24-48hrs	273	1339	5107	1981	296	607	29	2154	116319
	48-72hrs	276	1351	5285	2140	382	782	30	2133	114623
RURAL	0-6hrs	221	824	1921	979	57	114	60	4850	66499
	6-24hrs	457	1570	4598	2080	185	370	61	4852	252098
	24-48hrs	564	1850	7654	3034	394	788	61	4836	334163
	48-72hrs	620	1938	9191	3657	572	1144	61	4806	332714
Spring										
	Retention time	5% (m)	Median (m)	95% (m)	Mean (m)	SE (m)	95% CI (m)	N_{ind}	N_{days}	$NSDE$
URBAN	0-6hrs	74	477	1510	653	67	140	24	1581	40639
	6-24hrs	133	818	3560	1294	134	277	26	1951	152071
	24-48hrs	155	960	4713	1780	221	456	26	1971	200740
	48-72hrs	211	983	5293	2022	287	590	26	1947	198847
RURAL	0-6hrs	211	856	1915	925	81	164	39	1790	36307
	6-24hrs	408	1426	4456	1956	293	594	39	1801	140759
	24-48hrs	498	1577	7413	3012	648	1313	38	1782	186757
	48-72hrs	509	1598	9975	3699	909	1842	38	1764	185270
Summer										
	Retention time	5% (m)	Median (m)	95% (m)	Mean (m)	SE (m)	95% CI (m)	N_{ind}	N_{days}	$NSDE$
URBAN	0-6hrs	97	557	1404	679	63	131	22	1659	30672
	6-24hrs	151	1014	3437	1299	125	258	25	2044	108467
	24-48hrs	218	1224	4189	1619	173	356	25	2052	143518
	48-72hrs	261	1243	4560	1753	199	410	25	2030	142167
RURAL	0-6hrs	232	777	1687	778	40	80	52	3043	37754
	6-24hrs	440	1386	3495	1458	79	158	52	3043	133562
	24-48hrs	531	1581	6025	1928	145	291	51	3022	175778
	48-72hrs	569	1661	7649	2208	202	406	50	3005	174094
Winter										
	Retention time	5% (m)	Median (m)	95% (m)	Mean (m)	SE (m)	95% CI (m)	N_{ind}	N_{days}	$NSDE$
URBAN	0-6hrs	137	568	1476	664	47	95	30	1960	36466
	6-24hrs	221	1025	3428	1317	118	241	30	2114	130787
	24-48hrs	306	1244	4549	1838	218	445	30	2102	172507
	48-72hrs	322	1296	4758	2134	315	644	30	2082	170731
RURAL	0-6hrs	232	935	2368	1114	122	245	50	2838	36757

6-24hrs	486	1717	5676	2175	153	307	48	2841	129551
24-48hrs	615	1934	9190	3165	324	651	48	2808	171960
48-72hrs	679	2002	10955	3840	493	992	47	2778	170755

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38 **Figure S1** - Legend for Landcover map in Figure 1a-1b and Figure S2a- S2b.



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Figure S2 Background landcover for Figure S1. Figure S2a and FigureS2b represent enlarged areas a. and b. from Figure S2 (top map). Legend for landcover types represented in S2a and S2b given by Figure S1.

