

**Long term snow tracking of red fox (*Vulpes vulpes*) and martens (*Martes* spp.) data indicates an increase in the number of mesocarnivores in urban area of Warsaw**



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# urban carnivores: widespread, plastic and adaptable

- ❧ urban carnivores – abundant in cities around the world
- ❧ typically opportunistic foragers
- ❧ widespread and common species
- ❧ with high degree of habitat plasticity



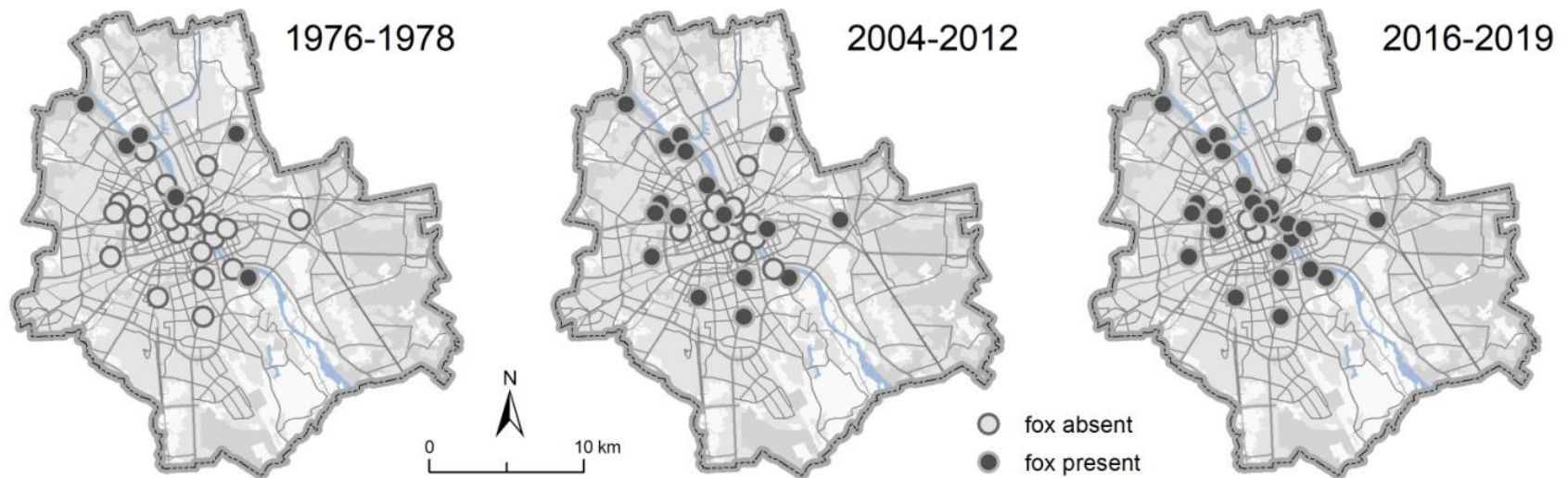
- ❧ easily-adapted, also to 'big city life' (Bateman & Fleming, 2012)
  - ❧ changes in activity and space use, food composition, social structure, home range size, density...

# carnivore densities

- ❖ red fox densities can be very diversified (0.001-37 ind./km<sup>2</sup>) in dependence of many factors: habitat-related food availability (Bateman & Fleming, 2012), winter severity (Bartoń & Zalewski, 2007), disease-induced mortality (Soulsbury et al., 2007)
- ❖ the highest density of foxes has been observed in urban areas and this is one of the most frequently reported feature of urban fox populations (Baker et al., 2001; White et al., 2006)
  - ❖ it is caused by high food availability
  - ❖ the consequences of increased density are epizooties in red fox population, what results in high mortality of individuals
- ❖ although stone marten densities are not as high as those of foxes, martens also tend to reach higher densities in urban areas (Herr et al., 2009)

# urban carnivores in Warsaw

- stone marten occurs in the whole city, beech marten only in bigger forests in the outskirts
- first observations of foxes in Warsaw were noticed in 1890s (Wałęcki, 1881)
- a spread of foxes in the city was recorded in the recent decades (Jackowiak et al., 2021)
  - primarily colonized forest (including riparian forests)
  - the whole city area was colonized by 2015

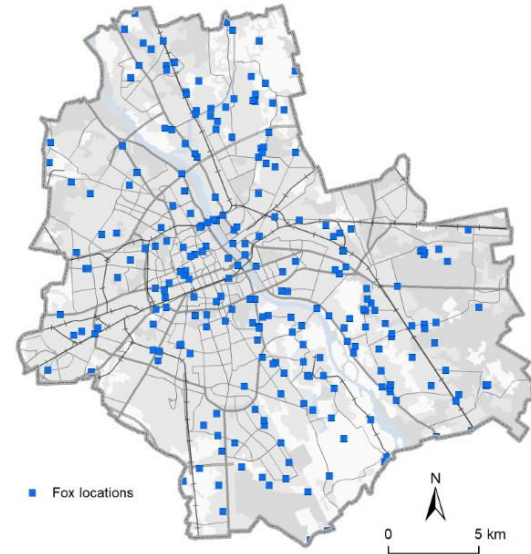


Colonization of 29 randomly selected green areas in Warsaw in 1976-2019 (Jackowiak et al., 2021, Scientific Reports).

# urban carnivores in Warsaw

## WHAT DO WE ALREADY KNOW

- ❧ Gradually increasing number of incidents with carnivores in the city in 1998-2015 (Krauze-Gryz et al., 2016; Jackowiak et al., 2021)
- ❧ The highest probability of incident with carnivores was recorded in densely populated habitats (built-up area, low-density housing)



*Location of 263 incidents with foxes in Warsaw in 1998-2015 (Jackowiak et al., 2021).*

## WHAT WE DON'T KNOW?

- ❧ What is the density of red fox and martens in Warsaw?
- ❧ In which habitats their densities are the highest?
- ❧ How the densities changed in different habitats since 1970s?

# aims of the study



→ density assessment of red fox and martens (stone and beech martens) in Warsaw in 2015-2021

→ comparison of densities of urban carnivores in three periods: 1976-1978 (Goszczyński J., unpubl.), 2005-2008 and 2015-2021

→ identification of habitats with highest densities of carnivores

→ identification of density changes during subsequent periods in different habitats

# study area

city area: 517 km<sup>2</sup>

18 districts

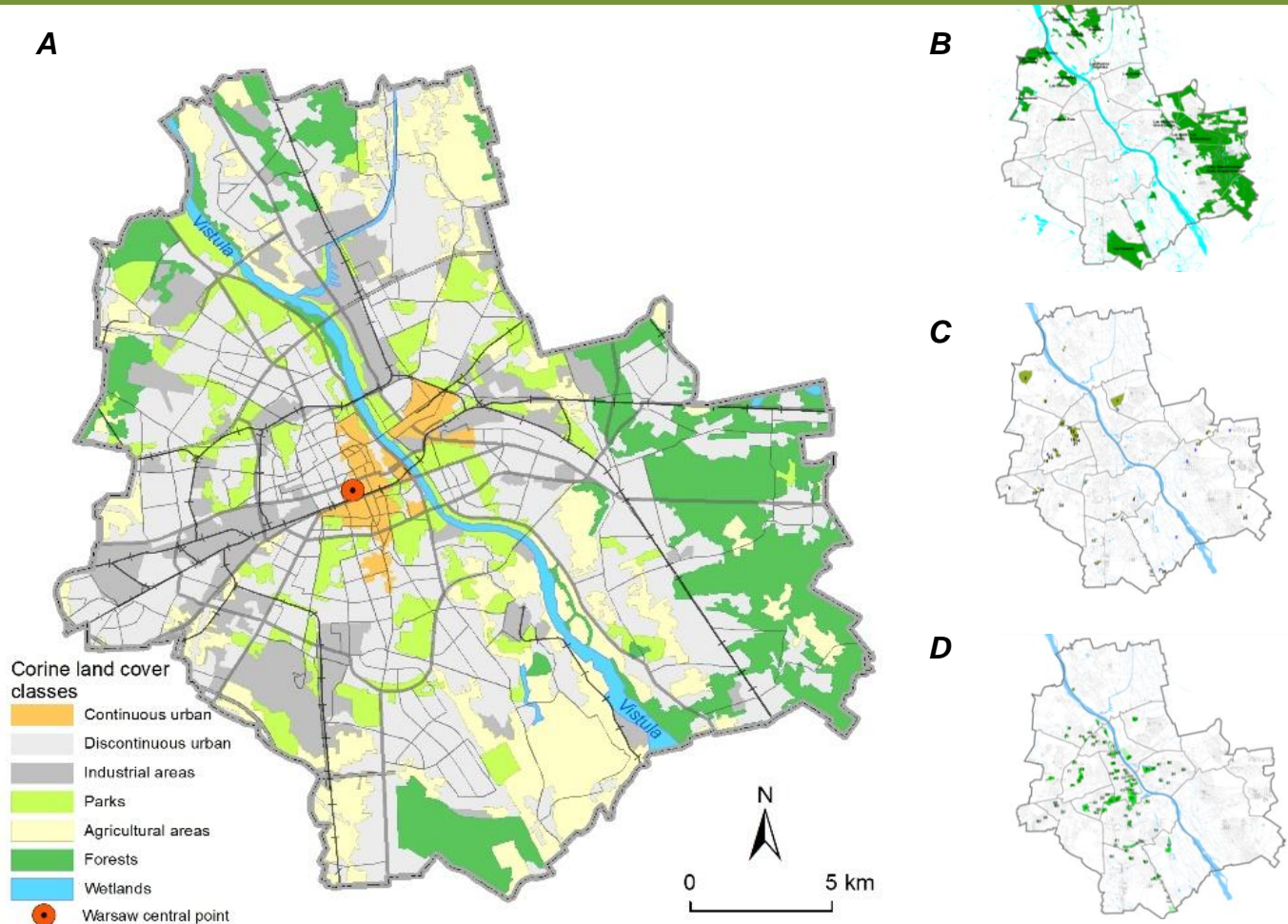
share of green areas: up to 63% (Luniak et al., 1997)

population: 1,778,000

population density: 3437 inh./km<sup>2</sup>

forests (~8000 ha; ca. 15% urban area) mostly in peripheral zone

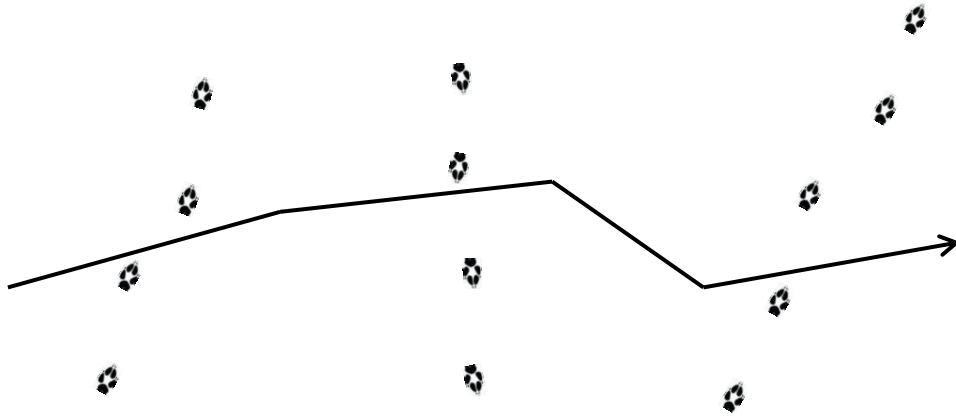
important ecological migration corridor – the Vistula River valley



*Distribution of green areas and other habitats in Warsaw. The Palace of Culture and Science, assumed as the most central point of the city is marked (A). The smaller maps show: distribution of forests (B), cemeteries (C) and parks (D) in Warsaw.*

# materials and methods

## density assessment



### Winter snow tracking:

counting tracks of carnivores that cross the transect route line

conversion of tracks number per one kilometer of transect and per 24 hours of snow cover presence (relative density index)

conversion to absolute density (ind./km<sup>2</sup>) by using Prikłonski formula (1965):

$$D \text{ (N ind./100 ha)} = 1.57 \times (\text{N tracks/km/24 hour}) / \text{DMD}$$

DMD – daily movement distance



# materials and methods

## density assessment

### **Winter snow tracking:**

tracking after 24 hours after snowfall (or earlier, but only if snowfall occurred before the night starts) and no longer than 96 hours after last snowfall

values of daily movement distance were adopted after Goszczyński (1986): 13.8 km for red fox and 6.8 km for martens

density estimated done for the whole city area and for nine categories of habitat: allotment gardens, built-up area, cemeteries, forests, low-density housing, open areas, parks, riparian and ruderal

# materials and methods

## density assessment

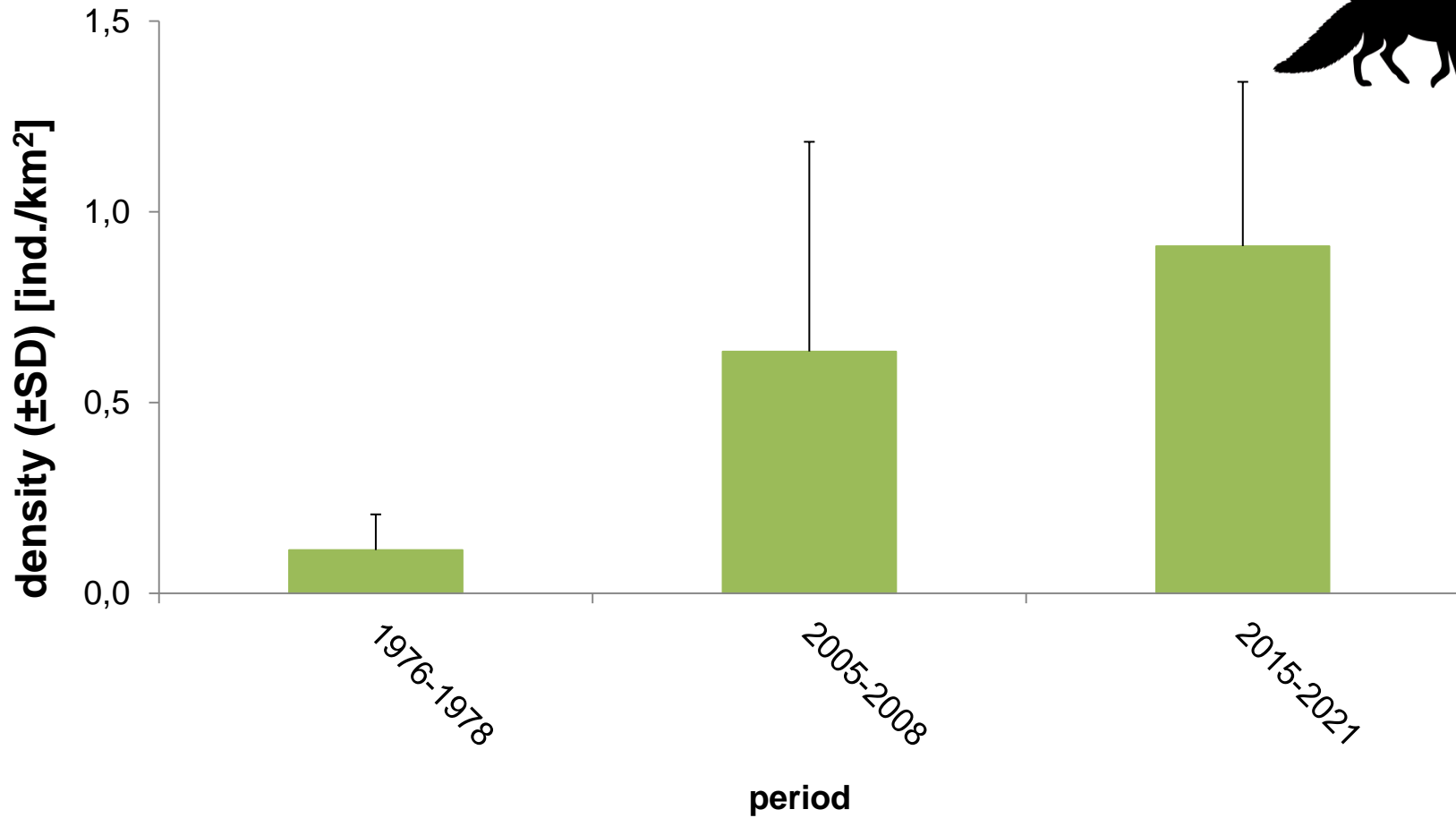
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<b>habitat category</b>	<b>habitat category characteristics</b>
allotement gardens	areas of non-commercial gardening and food plant cultivation, usually managed by Polish Allotment Federation
built-up areas	dense urban development
cemeteries	present and historical burial places
forests	all type of coniferous and deciduous forests in the city, including managed forests and protected forests
low-density housing	sparsely and discontinuos urban development
open areas	areas without urban development and forest or shrub cover with various degree of anthropogenic modification, e.g. agriculture lands, some sport facilities, lawns
parks	parks and squares
riparian	riparian forests along the Vistula River
ruderal	areas around streets and roads, railways, industrial areas

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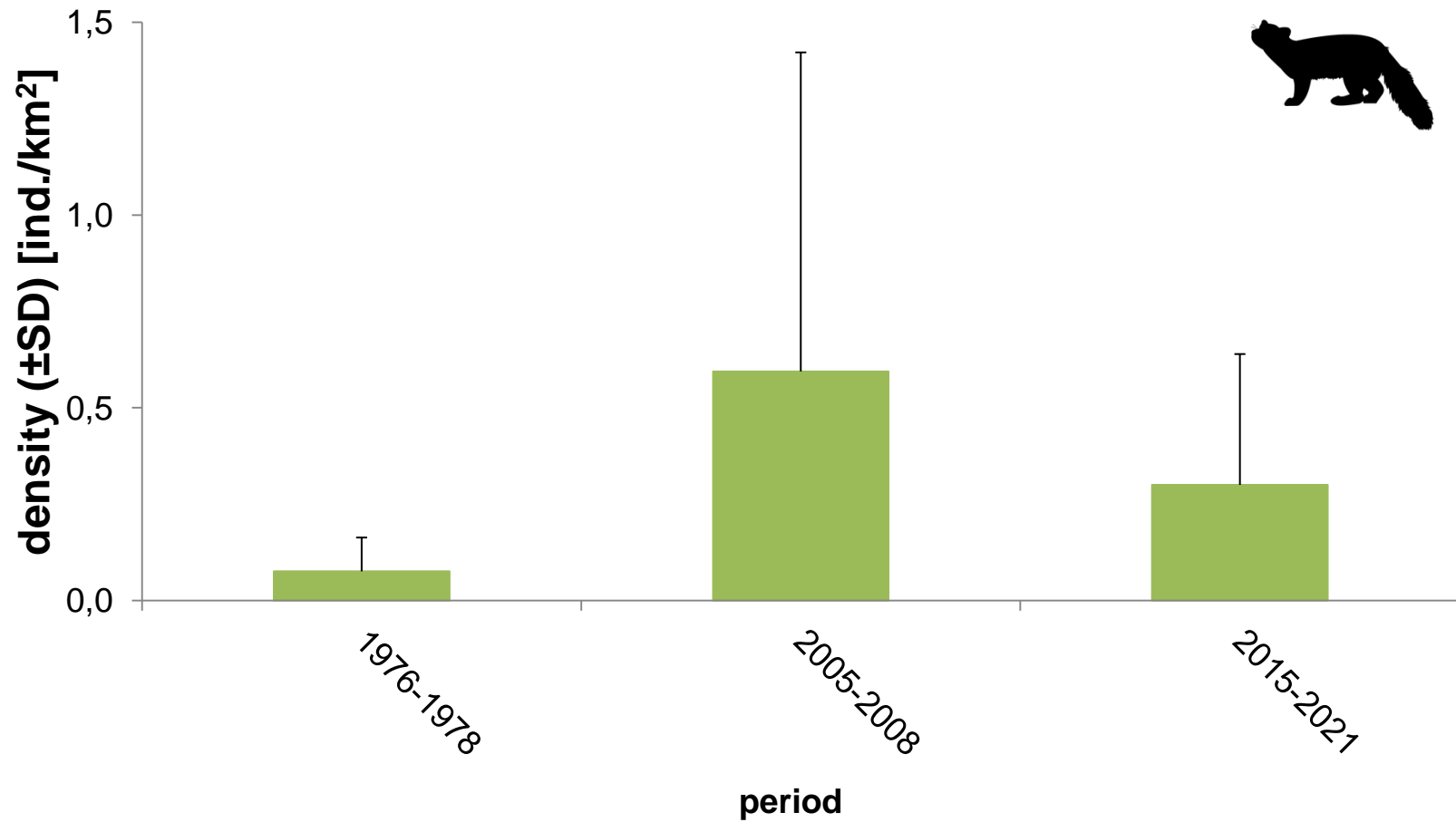
# results

comparison of fox density between periods



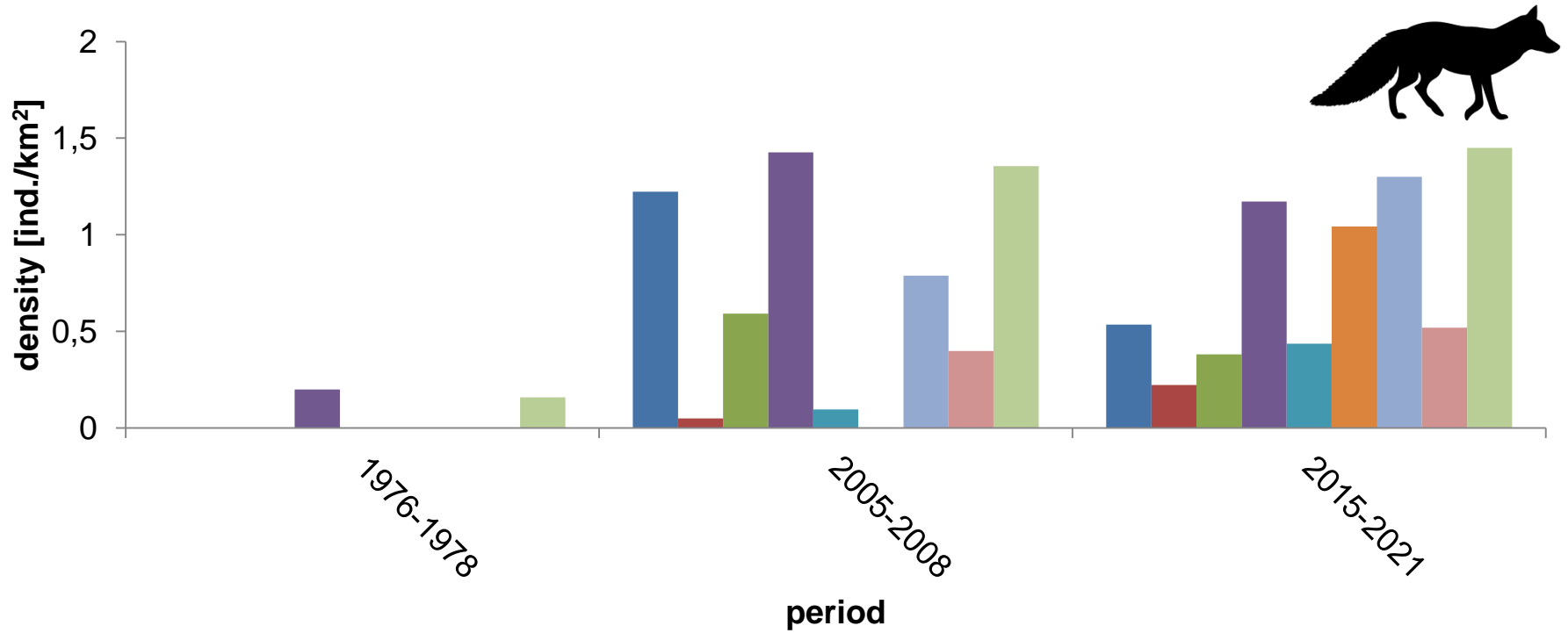
# results

comparison of martens density between periods



# results

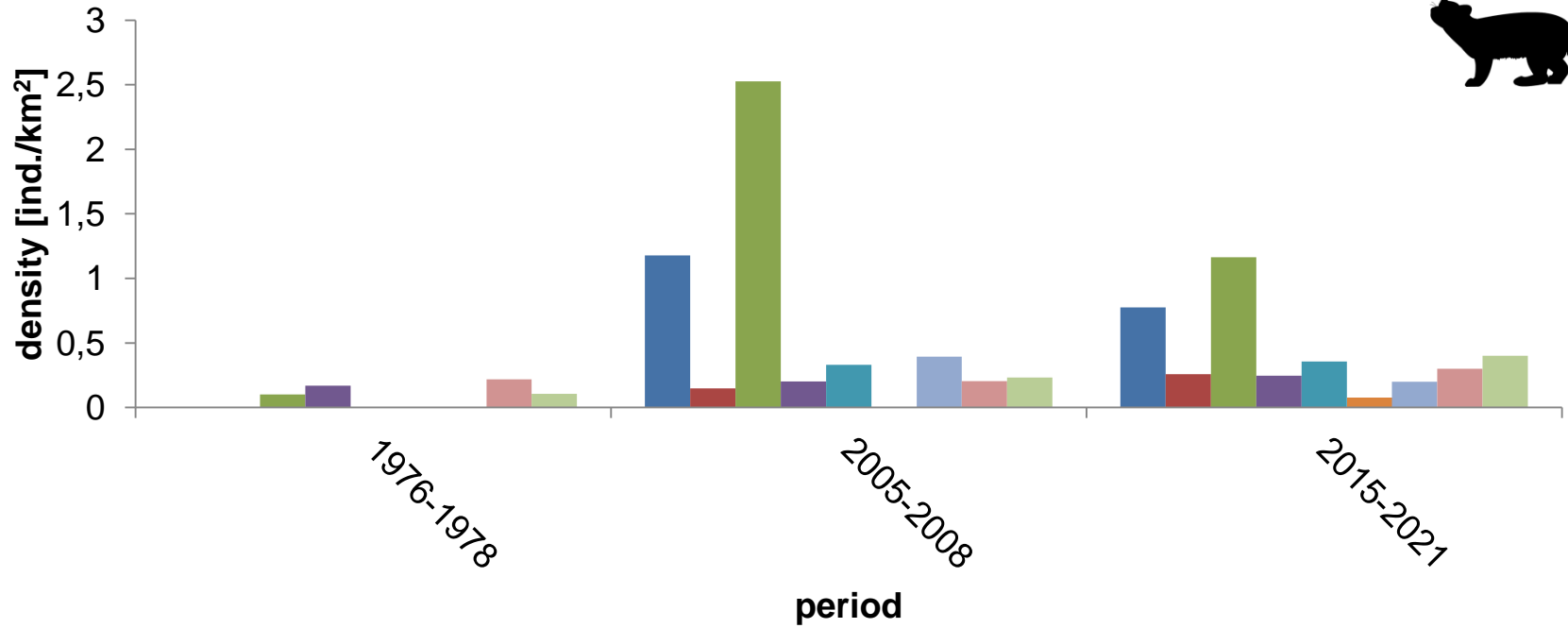
## red fox density in habitats in periods



- allotment gardens
- built-up areas
- cemeteries
- forests
- low-density housing
- open areas
- parks
- riparian
- ruderal

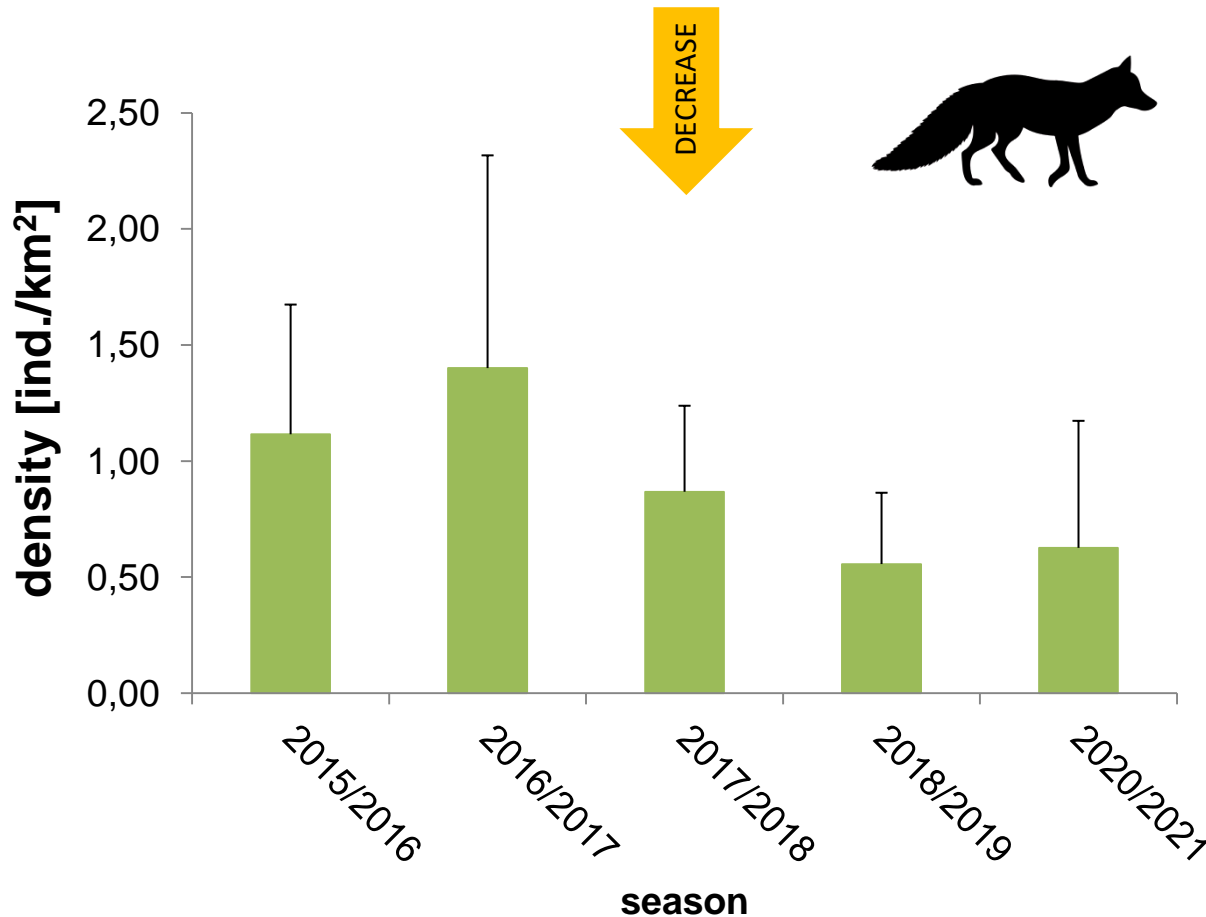
# results

## martens density in habitats in periods



# Results

## red fox density in 2015-2021

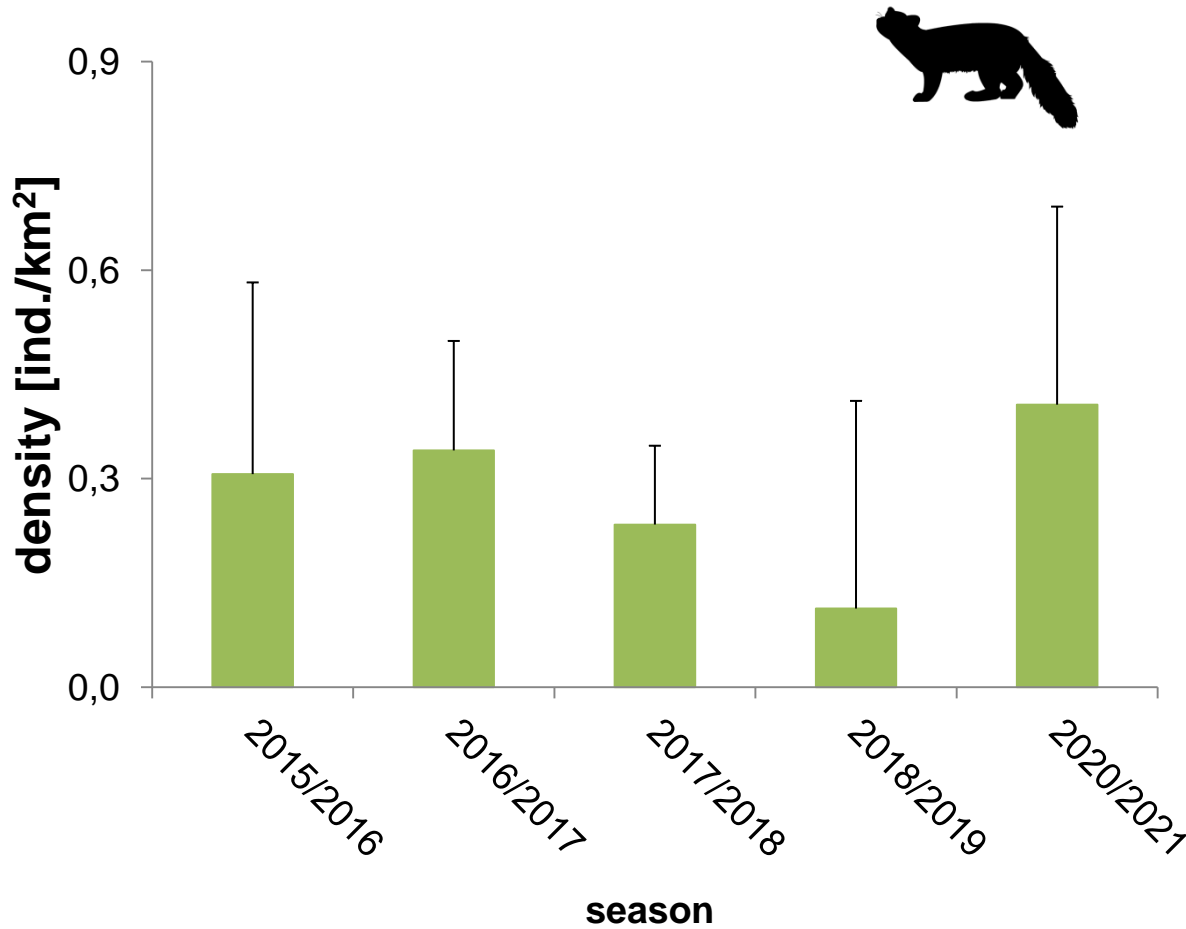


season	transect length [km]
2015/16	190
2016/17	163
2017/18	125
2018/19	98
2020/21	185

*lack of the data from 2019/2020 season, due to insufficient snow cover*

# results

## martens density in 2015-2021



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# results

density decrease – is the sarcoptic mange the answer?

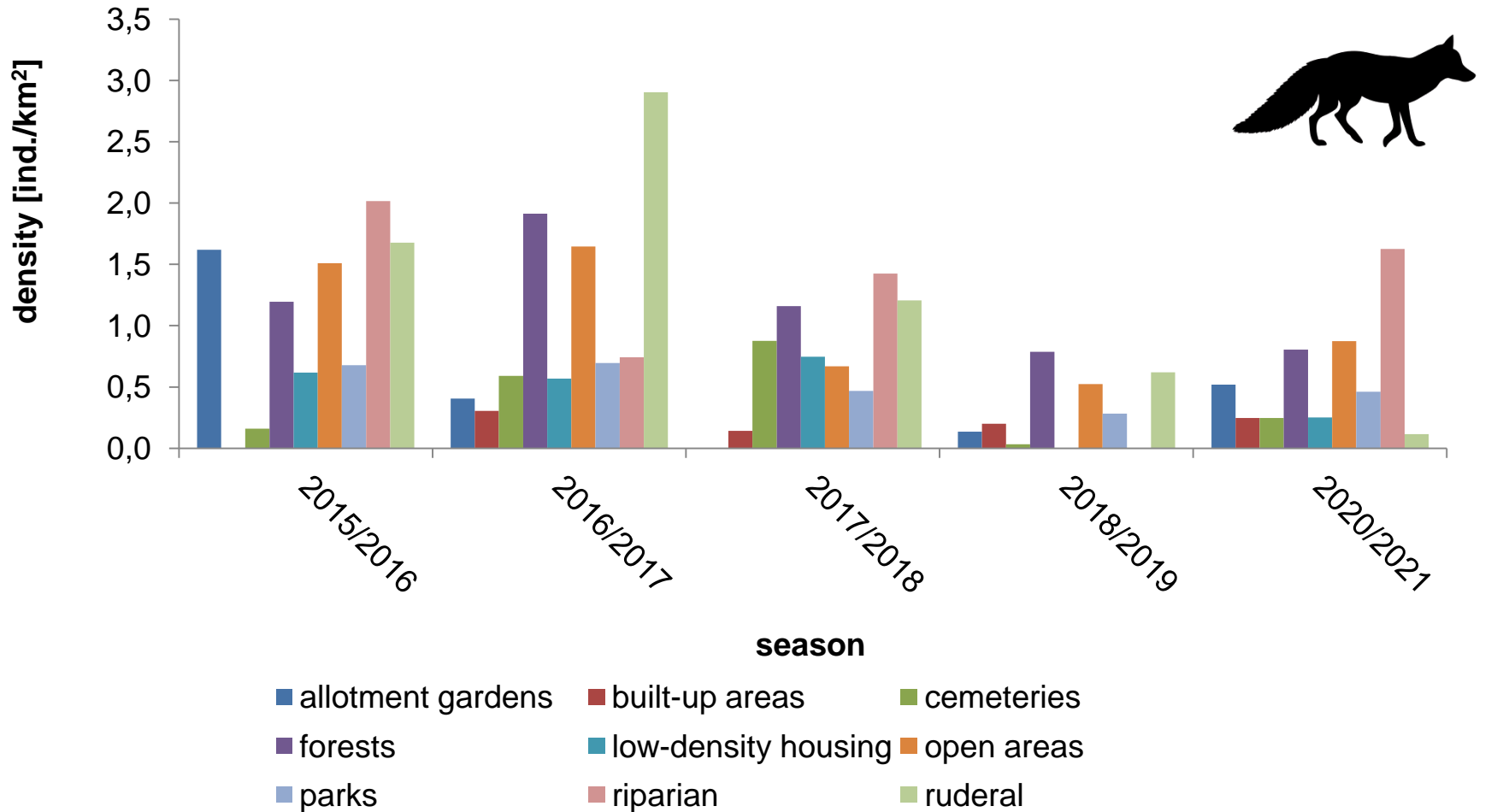


# results

season	fox density [ind./km <sup>2</sup> ]	individuals with mange symptoms [%]	individuals in infestation phase [%]		
			first phase	second phase	third phase
2015/16	1.12	25	80	-	20
2016/17	1.40	20	67	33	-
2017/18	0.87	28	86	14	-
2018/19	0.56	37	59	38	3
2020/21	0.63	?	?	?	?

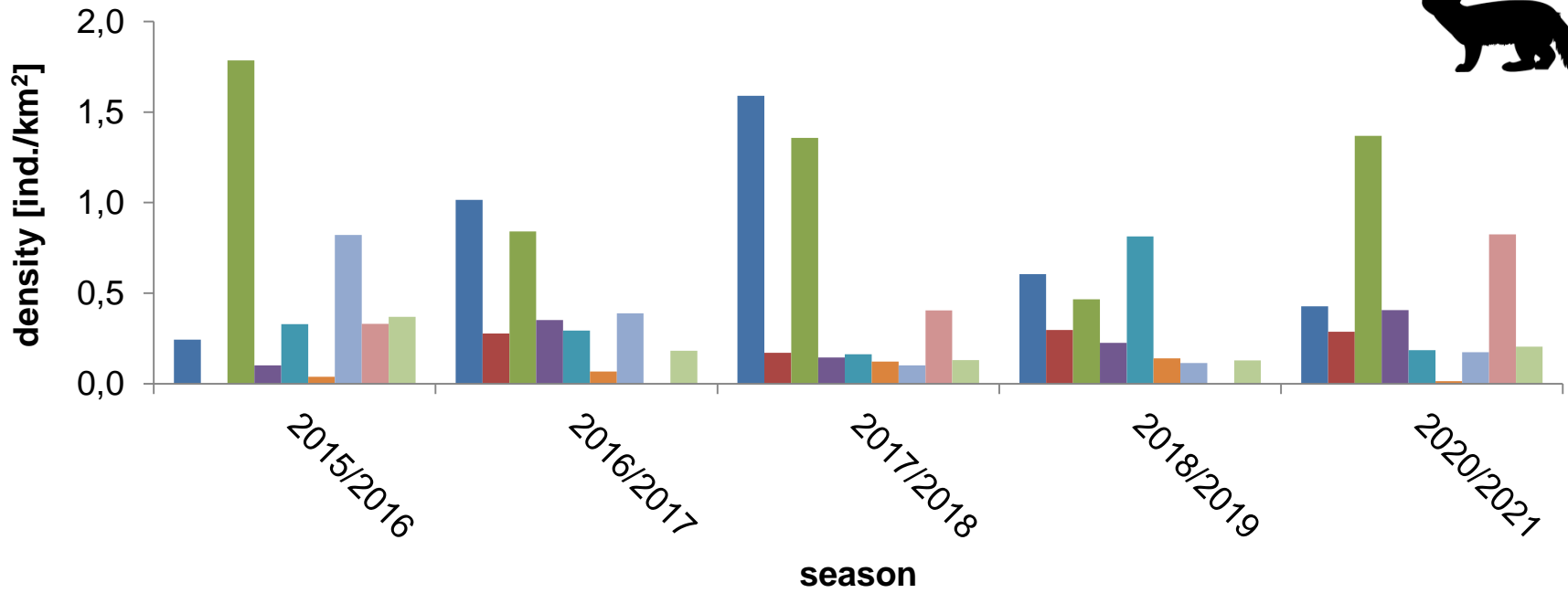
# results

## red fox density in habitats



# results

## martens density in habitats



- allotment gardens
- built-up areas
- cemeteries
- forests
- low-density housing
- open areas
- parks
- riparian
- ruderal

## to summ up

- ❧ data on density of red fox and martens showed gradual rise in their abundance in Warsaw, in particular:
  - 1) colonization new habitats, from natural to human-modified ones
  - 2) wider occurrence of carnivores in human-modified habitats in subsequent periods
  - 3) gradual increase in number of carnivores in the whole city area
- ❧ densities of martens were lower than fox densities and were more stable in the whole study period
- ❧ of all habitats, forests and riparian forests seem to play a crucial role in maintenance and development of urban populations of carnivores

## to summ up

- ❗ quite low densities of mesocarnivores in habitats, which are preferred and most important for wildlife in other cities (e. g. Tolhurst et al., 2020), can point to lower level of population development in Warsaw or to inconvenient conditions for foxes and martens in these habitats
- ❗ decrease of foxes and martens densities from 2017-2018 are hard to explain, but it could be related to higher percent of individuals with mange symptoms and to a higher percent of individuals in last phase of mange infestation



Thank  
you for  
attention!

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