**Methods**

**The study area**

This study was conducted in Helagsfällen, Jämtland county, which is the southernmost of three geographically isolated arctic fox subpopulations in Sweden (Dalén *et al.* 2006). The Helags population covers an area of 1920 km2 (står 3400 km2 i Norén et al 2016, vad gäller?) ((Angerbjorn *et al.* 2013) and is mostly comprised of typical Fennoscandian mountain tundra. Productivity is low and the ground surface is characterised by grass heath, dry heath, fens, bogs, rocks and firn (källa behövs). Arctic fox demography and ecology is highly influenced by cyclic prey populations (lemmings and voles) (Meijer *et al.* 2013) and the study period spanned over five prey population peaks (Hasselgren *et al.* 2018).

Intense conservation actions have been carried out on this population since 1999, including support feeding at some dens, red fox culling, yearly den inventories and ear tagging of individuals (Angerbjorn *et al.* 2013). Therefore, the 68 known dens can be considered to be all that are present in the area (jag har 78 i mina filer). Much due to these conservation efforts, the population increased from four breeding individuals in 2000 to 58 in 2015 and virtually all reproductive dens have been recorded every year (Noren *et al.* 2016, Hasselgren *et al.* 2018).

**Den parameters**

Spring-active and reproductive dens were recorded for each year of the study period.

The distance from reproductive dens to other reproductive dens was measured along with the distance from reproductive dens to red fox reproductive dens and locations of shot red foxes. Six dens have been extensively studied throughout the period with snap-trapping of rodents (200 trap nights per den per year) and 6 km bird transects (1.5 km lines in a cross with the den in the centre) to estimate prey abundance. In addition I measured den characteristics on these six dens and four additional ones. Snow depth was recorded at 10 points with a 2 metre radius from the estimated centre of the den. At the same points soil temperature was measured at 2 cm depth. I also measured snow -free area and number of open burrows in late April and early May 2018. In late June and early July I returned to the same ten dens and measured the area, slope angle and direction using a hand held compass, number of open burrows and soil temperature at 10 cm depth at 10 points at a 2 m radius from the estimated centre of the den.

**Den parameter estimation using geographic information systems**

All geographic information system (GIS) computations were calculated in QGIS 3.0 Girona and RStudio. Elevation of dens was calculated using 2 metre elevation raster (GSD-Höjddata, grid 2+, source: Lantmäteriet, downloaded 2018 – 05 - 31). Since many dens are located near the Swedish - Norwegian border topographical features of interest were added for both sides of the border. Distances from dens to streams and lakes and total water cover within a 1.5 km radius from the dens were calculated using Fastighetskartan Hydrografi Vektor, source: Lantmäteriet, downloaded 2018 – 06 – 07 for the Swedish side. Total area of bogs within a 1.5 km radius from the dens was calculated using Fastighetskartan Markdata Vektor source: Lantmäteriet, downloaded 2018 – 08 – 07 for the Swedish side. Distances from dens to treeline were calculated using Vegetation Fjällkedjan Vektor, source: Lantmäteriet, downloaded 2018 – 06 – 08 for the Swedish side. Groups of trees that were not connected to continuous low land forest were excluded. For the Norwegian side N50 Kartdata, Source: Kartverket, downloaded 2018 – 06 – 08 was used for all analyses. Lemming spatial distribution around dens was calculated using the model developed by Le Vaillant *et al.* (2018).

**Ptarmigan inventories**

Ptarmigan abundance was estimated using the Wildlife Triangle Scheme (Lindén *et al.* 1996, Hellström *et al.* 2014) in two separate surveys, conducted in late April to early May and in late June to early July 2018 on 10 dens. Visual observations of ptarmigan, calls, droppings and snowtracks were counted on 12 km triangle shaped transects around 10 arctic fox dens in Helags. The triangles were placed with the den in the centre. If steep terrain did not allow for a central placement of the den the triangle was placed with the den in a corner. The species was determined for each observation if possible, otherwise genus was recorded. GPS -coordinates were recorded with each observation. Distance to visual birds was measured with a Nikon Laser Rangefinder PROSTAFF 3I and angle was measured using a hand held compass. Distance to droppings and unseen calling birds was estimated.

**Statistical analyses**