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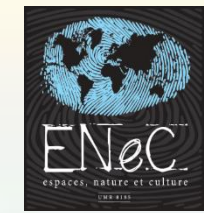
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Wild reindeer migratory pattern (Hardangervidda, Norway): what resilience under climate change?

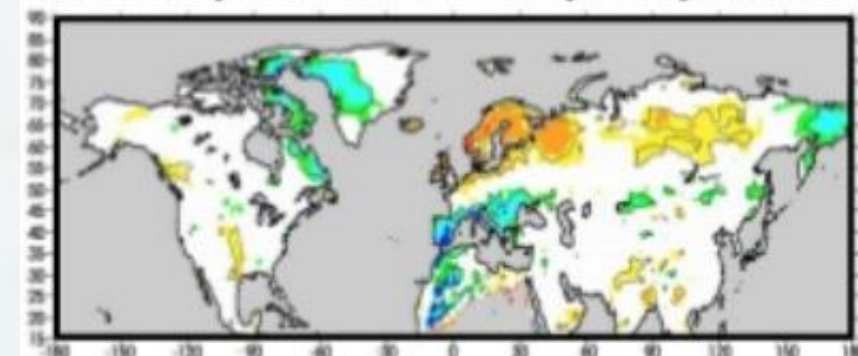


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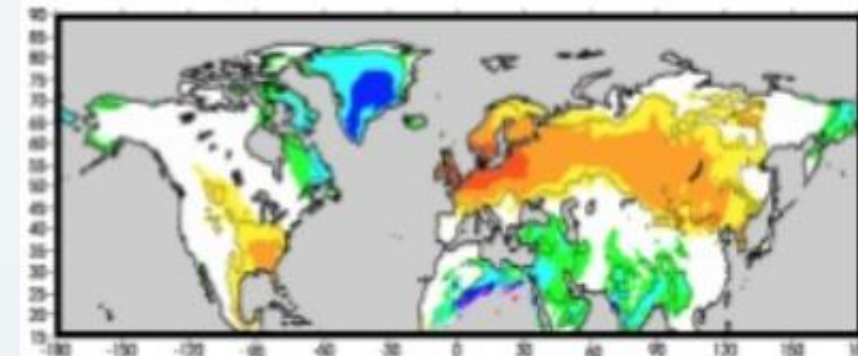


Introduction (1)

ERA-Interim (1990-2010)
NAO impact on winter precipitation



NAO impact on winter temperature



Casado et al (2013)

Recent global warming has strong impacts on both atmospheric and climatic variability.

In Europe, Northern Atlantic Oscillation is the most occurring teleconnection mode, particularly during winter. (Hurrell, 1995) Positive phases are associated with milder and wetter types of weather than average (fig.1; Casado et al. 2013).

Associated with increased annual temperatures in Scandinavia, milder and wetter conditions in winter have a lot of direct and indirect effects on sub-

arctic ecosystem structure (hydrological and cryosphere cycle) and functions (borealization of floristic and faunistic communities, Wrona et al., 2016)

Figure 1: Impacts of NAO on winter precipitations and temperatures (1990-2010), source: P. Ortega, 2015, Our Common Future Conference, Paris, 2015 July 7-10

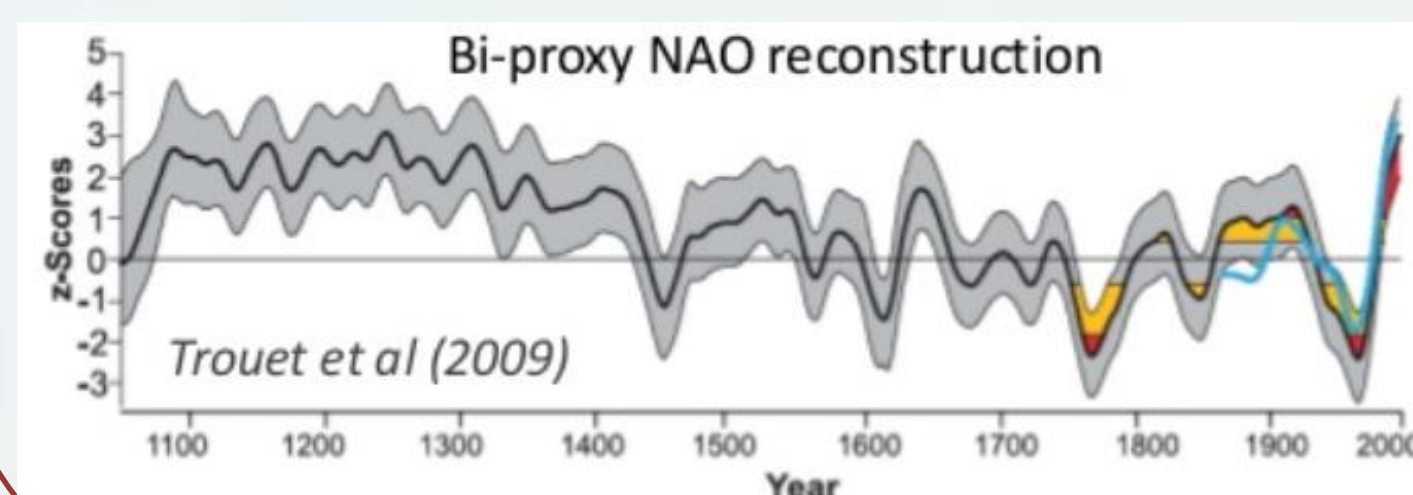


Figure 2: Winter NAO reconstruction using Scotland and Morocco precipitation as proxies (grey area and black line) and observed NAO index series (blue line), source: P. Ortega, 2015, Our Common Future Conference, Paris, 2015 July 7-10

Material and methods

DATA ACQUISITION

- Hardangervidda wild reindeer' GPS tracks, 2007-2010, (Cagnacci et al. 2016, <https://datadryad.org>)
- NAO daily index, 2007-2010, www.cpc.ncep.noaa.gov
- Local meteorological records, 2007-2010, Høydalsmo & Rauland stations (www.eklima.org)

CENTRALIZATION

- From 3 hours GPS logs to 1 day (mean)
- From individuals to the whole monitored reindeer population
- One day from November to February (2007-2010) = 1 latitude, 1 longitude, 1 NAO index, 1 T°C mean, 1 precipitation...

STATISTICS

- Linear regression (Spearman correlation coefficient) between recorded GPS latitudes and longitudes, atmospheric and meteorological tested factors
- Selection of significant correlations ($\alpha \geq 0,3$; $p \leq 0,05$)

Introduction (2)

In 2016, *Rangifer tarandus* L. (wild reindeer) has been in Norway, the sub-classified as Vulnerable species by the International Union for Conservation of Nature (Gunn, IUCN, 2016).

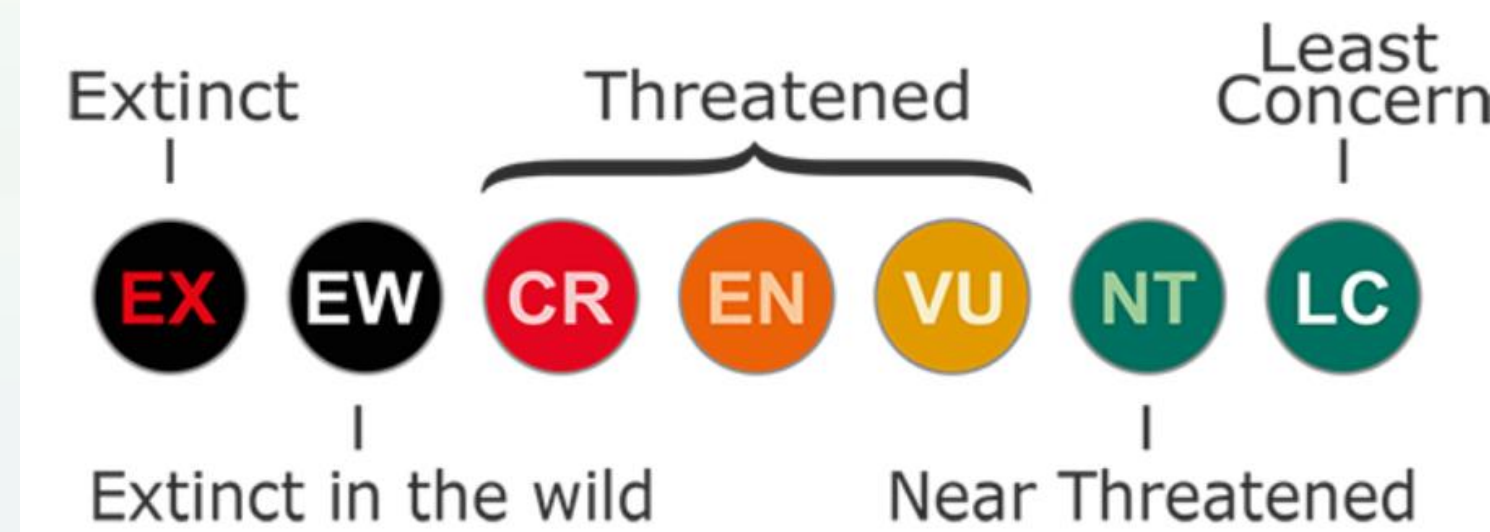
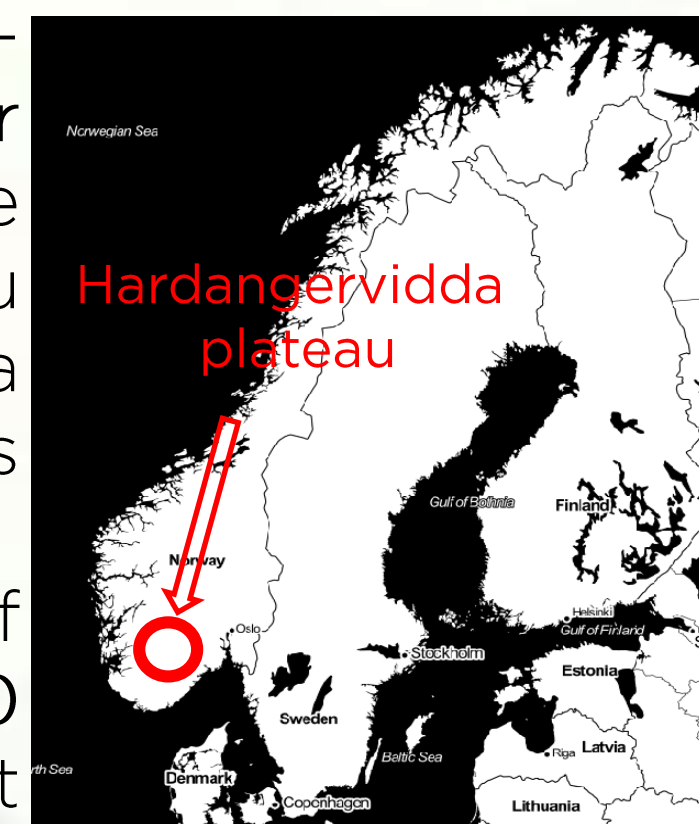


Figure 3: International Union for Conservation of Nature classification of threatened species. Statut depends on population, changing environment and predation. Source: IUCN

located in the Hardangervidda plateau (fig. 4) is currently facing a constant decline of its population since 1950. For this herd, number of reindeer was about 30 000 during 60's, and was about 5000 in 2010 (Uboni, 2016).

Figure 4: Hardangervidda plateau location in Fennoscandia (R. Courault, 2018)



Results

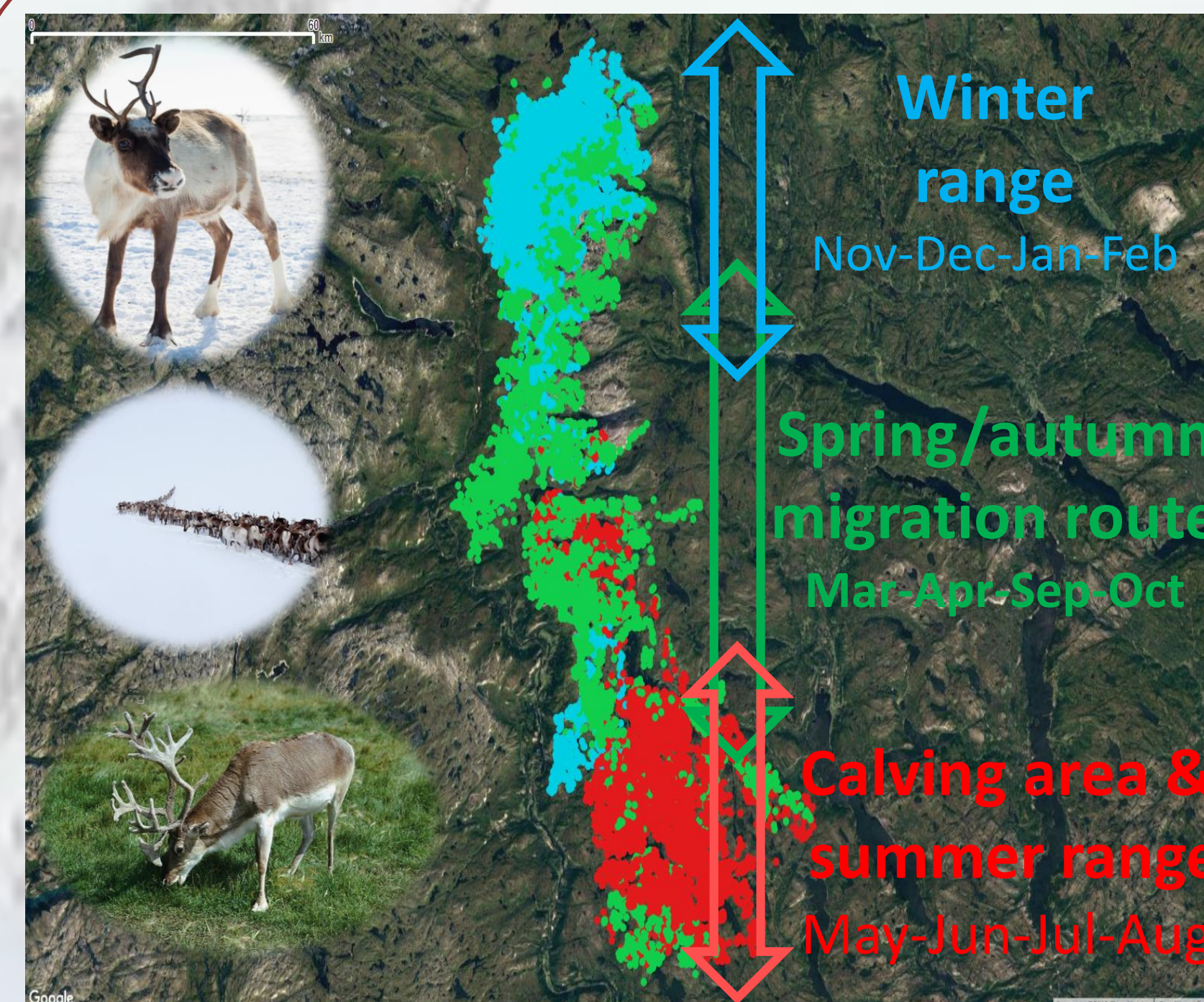


Figure 5: Monthly representation of wild reindeer GPS tracks (source: datadryad.org, Cagnacci et al., 2013; Realization R. Courault (2018))

| Positive correlations | NAO | T°C mean | T°C min | T°C max | Precipitation | Snowdepth | TOTAL |
|------------------------|-----|----------|---------|---------|---------------|-----------|-------|
| GPS position latitude | 1 | 1 | 2 | 4 | 0 | 3 | 11 |
| GPS position longitude | 4 | 2 | 1 | 1 | 4 | 1 | 13 |
| TOTAL | 5 | 3 | 3 | 5 | 4 | 4 | 24 |
| Negative correlations | NAO | T°C mean | T°C min | T°C max | Precipitation | Snowdepth | TOTAL |
| GPS position latitude | 5 | 4 | 5 | 3 | 11 | 4 | 32 |
| GPS position longitude | 3 | 2 | 1 | 2 | 0 | 5 | 13 |
| TOTAL | 8 | 6 | 6 | 5 | 11 | 9 | 45 |

Figure 6: Table of significant ($\alpha \geq 0,3$; $p \leq 0,05$) Spearman correlations between reindeers' latitude and longitude (lines) and atmospheric/climatic tested factors (rows). Realization: R. Courault (2018)

Figure 5 displays every reindeers' GPS track according to the month it has been recorded (2007-2010). Three main seasonal vital areas are visible here, even if mapped GPS logs show a certain heterogeneity (for example blue points/winter tracks inside calving area/red points).

Statistical results (fig. 6) shows significant relationships between reindeers' GPS location, NAO values and climatic records. The more the NAO is positive, the more GPS tracks tend to be southerner or westerner (11 significant correlations/13). NAO+ phases are strongly correlated with mild and wet weather (17 positive relationships between NAO/T°C over 19 significant correlations; 11 positive relationships over 12 for NAO/Pmm). These results suggest that NAO+ phases are related to milder and wetter conditions, themselves related to movement patterns comparable to spring migration, initially toward calving areas. A longer time series, and/or other GPS-equipped reindeers' sub-populations would strengthen this results. A detailed-scale analysis of habitat selection during positive phase of NAO in winter would allow us to better understand resilience of reindeer to climatic variability.

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More informations

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