Remote sensing reveals environmental drivers of Dall sheep survival

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INTRODUCTION

Dall sheep (*Ovis dalli dalli*)

- Endemic to alpine areas throughout the ABoVE domain
- Often face extreme weather conditions such as heavy snowfall
- Recent declines in some populations have been attributed to harsh weather and climate conditions
- Exact mechanisms driving the declines are not known

Objective

- Evaluate effects of climate and vegetation productivity on survival of Dall sheep throughout the species' range in northwestern North America.

METHODS

Sheep and environmental data

- VHF and GPS telemetry data from 9 sites, 1997-2012 (Fig. 1)
  - *N* = 488 sheep (187 lambs, 301 adults)
- Seasonal environmental variables:
  - **Freeze-thaw frequency (FTF)** from NASA MEaSUREs passive microwave product[1]
  - **Max NDVI** from NOAA AVHRR sensor[2]
  - Snow water equivalent (**SWE**) from Daymet V.3[3]
  - Mean monthly **Temp & Precip** from SNAP
  - Regional cyclic patterns (**AO & PDO**) from NOAA

Data analysis

- Cox proportional hazard regression to examine the effect of environmental variables recorded during summer, winter, and the previous winter on annual survival rates of lambs and adults
- Identified most influential variables by creating a full additive model set and calculating relative variable importance (RVI)
- Found most parsimonious models using model selection approach based on additive models with the environmental variables as well as age for adults and birth mass for lambs

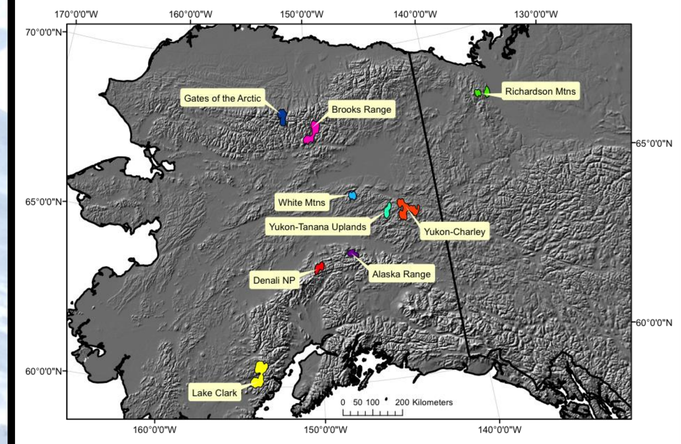

Figure 1: Dall sheep study sites, 1997-2012

RESULTS: Key Drivers

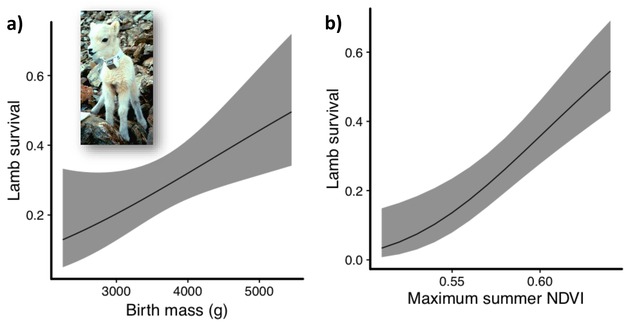

Figure 2: The most important predictors for lamb survival were (a) birth mass and (b) summer NDVI

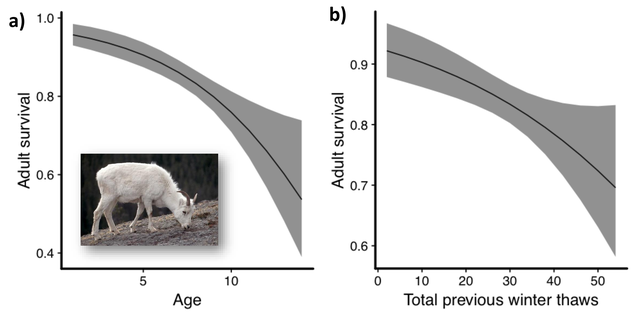

Figure 3: The most important predictors for adult survival were (a) age and (b) freeze-thaw frequency in the previous winter

RESULTS: Interactive Effects

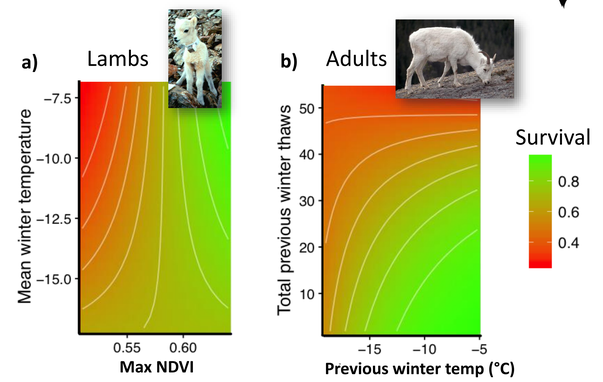

Figure 4: Warm winters increased: (a) lamb survival, but only when preceded by summers with high NDVI; (b) adult survival, but only when winter freeze-thaw frequency was low

CONCLUSIONS

- Regional climate cycles had weak effects: climatic conditions vary considerably among sheep populations
- Potential benefits of climate warming may be counteracted if wintertime freeze-thaw events markedly increase
- Results highlight the utility of multiple remotely- sensed environmental conditions for ungulate management
- In particular, passive microwave products provide valuable information about snow surface conditions and are currently underutilized by wildlife ecologists

CITATIONS

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[2] Vermote, E, C Justice, I Csiszar, J Eidenshink, R Myneni, F Baret, E Masuoka, R Wolfe, M Claverie, and NOAA CDR Program. 2017. NOAA Climate Data Record (CDR) of Normalized Difference Vegetation Index (NDVI), Version 4. doi:10.7289/V5PZ56R6

[3] Thornton, PE, MM Thornton, BW Mayer, Y Wei, R Devarakonda, RS Vose, and RB Cook. 2016. Daymet: Daily Surface Weather Data on a 1-km Grid for North America, Version 3. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1328

Sheep photos courtesy of S. Arthur