Remote sensing reveals drivers of Dall sheep survival
Assessing Alpine Ecosystem Vulnerability to Environmental Change Using Dall Sheep as an Iconic Indicator Species (Prugh-01)

- satellite RS products predicted sheep survival better than met data
- passive microwave RS provides key snow surface data, underutilized by wildlife ecologists
- benefits of warming (inc. NDVI) may be counteracted by increase in winter freeze-thaw events

NDVI predicts lamb survival
PM freeze-thaw predicts adult survival

van de Kerk et al. in review
The influence of snow conditions on Dall sheep productivity
Chris Cosgrove, Anne Nolin, Laura Prugh, Jeff Wells and Judy Putera (Prugh-01)

- Compared **22 years** of summer Dall sheep surveys in the Wrangell St Elias National Park to **7 snow indices** as simulated by **SnowModel** (Liston and Elder, 2006)

- Used **Lamb-to-ewe ratios** as a measure of Dall sheep productivity

- **Fall** conditions, and specifically mean **Sep snow depth**, are most important

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**Phase 1**

**Mean Sept. snow depth**

<table>
<thead>
<tr>
<th>Rank</th>
<th>Month</th>
<th>AICc</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sep</td>
<td>-79.06</td>
<td>0.999</td>
</tr>
<tr>
<td>2</td>
<td>Apr</td>
<td>-64.50</td>
<td>0.001</td>
</tr>
<tr>
<td>3</td>
<td>Apr</td>
<td>-61.62</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>Nov</td>
<td>-60.81</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Sep</td>
<td>-58.22</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>Sep</td>
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<td>0</td>
</tr>
<tr>
<td>7</td>
<td>Sep</td>
<td>-45.71</td>
<td>0</td>
</tr>
</tbody>
</table>

- **Mean Monthly Snow Depth** + (1 | Survey.unit.name)
- **Mean Monthly Forageable Area** + (1 | Survey.unit.name)
- **Mean Monthly Snow Density** + (1 | Survey.unit.name)
- **Sum Days of Mean SWE Loss ≥2 mm** + (1 | Survey.unit.name)
- **Mean Monthly Air Temperature** + (1 | Survey.unit.name)
- **Sum Days of Mean SWE Loss ≥2 mm** + (1 | Survey.unit.name)
- **Sum Total Monthly Snowfall** + (1 | Survey.unit.name)

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**Photo**: Laura Prugh (Prugh-01)

Cosgrove et al., in prep
Hard snow layers are important for ungulate foraging & travel.

Hard snow layers were mapped in the Wrangell St Elias National Park from 2002 to 2010 using the Calibrated Enhanced-Resolution Passive Microwave Daily EASE-Grid 2.0 Brightness Temperature ESDR (3.125 km and 6.25 km).

Promising results show linkages between mapped hard snow and mid-winter melt/refreeze events.

Currently the algorithm works over relatively flat terrain [rugged topography presents a problem].
Using 482 photo observations and 22 intensive interviews, we assessed rural community vulnerability to changing environmental conditions.

Cold et al. (in review) Ecology and Society
**River Ice Conditions**
- earlier spring breakup
- later fall freeze
→ narrowing window of “SAFE” ice for travel

- Riverbank Erosion
  - accelerating and occurring throughout summer
  - related to: increased winter groundwater discharge, earlier breakup, permafrost thaw
  → challenging boat navigation
  → floating debris destroying fish, wheels and nets

- Low Fall Water Levels & High Temps
  → both related to decreased daily moose harvest between 2000-2016

**Relative Vulnerability of rural communities**

*Phase 1*
Making Headlines in Alaska: Fall temp. effects on hunting & River ice safety issue

Warm weather meant tough hunting in GMUs 17B and C

Biologists and hunters are theorizing that moose laid low to escape the heat and inadvertently escaped the freezer.
Knowledge Exchange Meeting with elders from 4 YK Delta villages, Bethel AK

- Shared findings and perspectives of project team and local knowledge holders
- Local knowledge provides unique, long-term context for understanding complex processes
Multi-species analysis of spring phenology in large animals of Arctic-boreal N. America

Phenological responses of large animals to climate change at high northern latitudes are largely unknown...

Root et al., 2003

POSTER: Animals on the Move: Where, when & why have they been? (caribou, wolves, robins and moose)
**Goal:** To test hypotheses about relationships between ‘birth phenology’ & weather/climate, snow, and vegetation signals for 5 different species.

- compare & contrast within/across populations, species, time and space

<table>
<thead>
<tr>
<th>Species</th>
<th>events</th>
<th>ind.</th>
<th>events</th>
<th>Years</th>
</tr>
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<tbody>
<tr>
<td>Tundra caribou</td>
<td>Migration start and end</td>
<td>834</td>
<td>4014</td>
<td>1996-2017</td>
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<td>woodland caribou</td>
<td>Parturition timing</td>
<td>684</td>
<td>1096</td>
<td>1998-2017</td>
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<tr>
<td>golden eagle</td>
<td>Migration end</td>
<td>98</td>
<td>553</td>
<td>1993-2017</td>
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<tr>
<td>moose</td>
<td>Parturition timing</td>
<td>32</td>
<td>50</td>
<td>2008-12</td>
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<tr>
<td>wolf</td>
<td>Denning</td>
<td>148</td>
<td>227</td>
<td>2000-17</td>
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</tbody>
</table>

1796 animals
5940 phenological events

*Gurarie et al. in prep.*
Arctic Animal Movement Archive
A living archive of ABoVE AotM participants and other Arctic data

**Goal:** To enable long-term discoverability and collaborative re-use of animal movement data in ABRs.

- hosted at Movebank
- publicly discoverable
- study-specific access controlled by data owners
- dozens of participating organizations
- invitations & manuscript in progress
  - case studies to illustrate the potential of long-term, large-scale and multi-species data + env. covariates available via RS products and weather models.

Bohrer & Davidson *et al.* *in prep.*
Arctic Animal Movement Archive
A living archive of ABoVE AotM participants and other Arctic data

Phase 1

Who

<table>
<thead>
<tr>
<th></th>
<th>Locations</th>
<th>Animals</th>
<th>Projects</th>
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<tbody>
<tr>
<td>Total</td>
<td>8,376,906</td>
<td>4,106</td>
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<tr>
<td>Bears</td>
<td>66,659</td>
<td>42</td>
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<tr>
<td>Caribou</td>
<td>2,899,549</td>
<td>2,097</td>
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<tr>
<td>Moose</td>
<td>188,701</td>
<td>44</td>
<td>2</td>
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<tr>
<td>Raptors</td>
<td>931,433</td>
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<tr>
<td>Sheep</td>
<td>51,867</td>
<td>20</td>
<td>3</td>
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<tr>
<td>Songbirds</td>
<td>696</td>
<td>57</td>
<td>3</td>
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<tr>
<td>Waterbirds</td>
<td>3,653,708</td>
<td>1,072</td>
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<tr>
<td>Wolves</td>
<td>551,997</td>
<td>369</td>
<td>6</td>
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</tbody>
</table>

When

Bohrer & Davidson et al. in prep.
Thank you