

Laura Prugh



Alpine Ecosystem Vulnerability

14-TE14-0022

Co-PIs: Anne Nolin, David Verbyla, Todd Brinkman

Institutional Collaborations

1. National Park Service: J. Putera, K. Rattenbury, S. Arthur, J. Lawler, P. Sousanes
2. Alaska Department of Fish and Game: T. Lohuis, S. Brainerd
3. University of Idaho: J. Rachlow
4. Interworks Consulting (Colorado State): G. Liston
5. Yukon Territory Government: T. Hegel
6. Government of Northwest Territories: N. Larter, T. Davidson
7. Gwich'in Renewable Resources Board: K. Callaghan
8. Parks Canada (Kluane): C. Wong

And... but... therefore



- Dall sheep are an indicator of alpine ecosystem health, and signs point towards increasing ailment
- Lack of knowledge about changes in alpine ecosystems represents a critical gap
- We will conduct range-wide and localized analyses of alpine vegetation changes, snow conditions, and Dall sheep population trends to identify key factors linked to vulnerability and resilience

Science Questions

- 3 Tier 2 Science Questions addressed
 1. Section 3.1 (how are changes affecting critical ecosystem services, and how are societies responding)
 - *Link alpine ecosystem dynamics to the societal implications of altered sheep harvest*
 2. Section 3.4 (causes and consequences of changes in the hydrologic system)
 - *Characterize snowpack properties at a spatial scale and resolution relevant to wildlife management*
 3. Section 3.5 (how flora and fauna are responding to changes)
 - *Quantify changes in vegetation and snow extent in alpine ecosystems throughout the ABoVE domain from 1980-2018*
 - *Assess Dall sheep habitat selection and population viability throughout their distribution*


Science Objectives

- Tier 2 Science Objectives
 - Ecosystem Dynamics
 1. Objective 4 (impacts of changing snow conditions)
 2. Objective 6 (causes and impacts of greening and browning trends)
 3. Objective 7 (how spatial and temporal dynamics of fauna and habitat co-vary)
 - Ecosystem Service
 1. Objective 3 (influence of changes on subsistence opportunities)
 2. Objective 4 (impacts on local communities and management policies)

Ecosystem Dynamics


Ecosystem Services

Vegetation



Shrub expansion
Phenology **Productivity**

Snowpack




Icing **Extent** **Depth**

Dall sheep vulnerability



Survival
Movement **Recruitment**

Water supply








Tourism

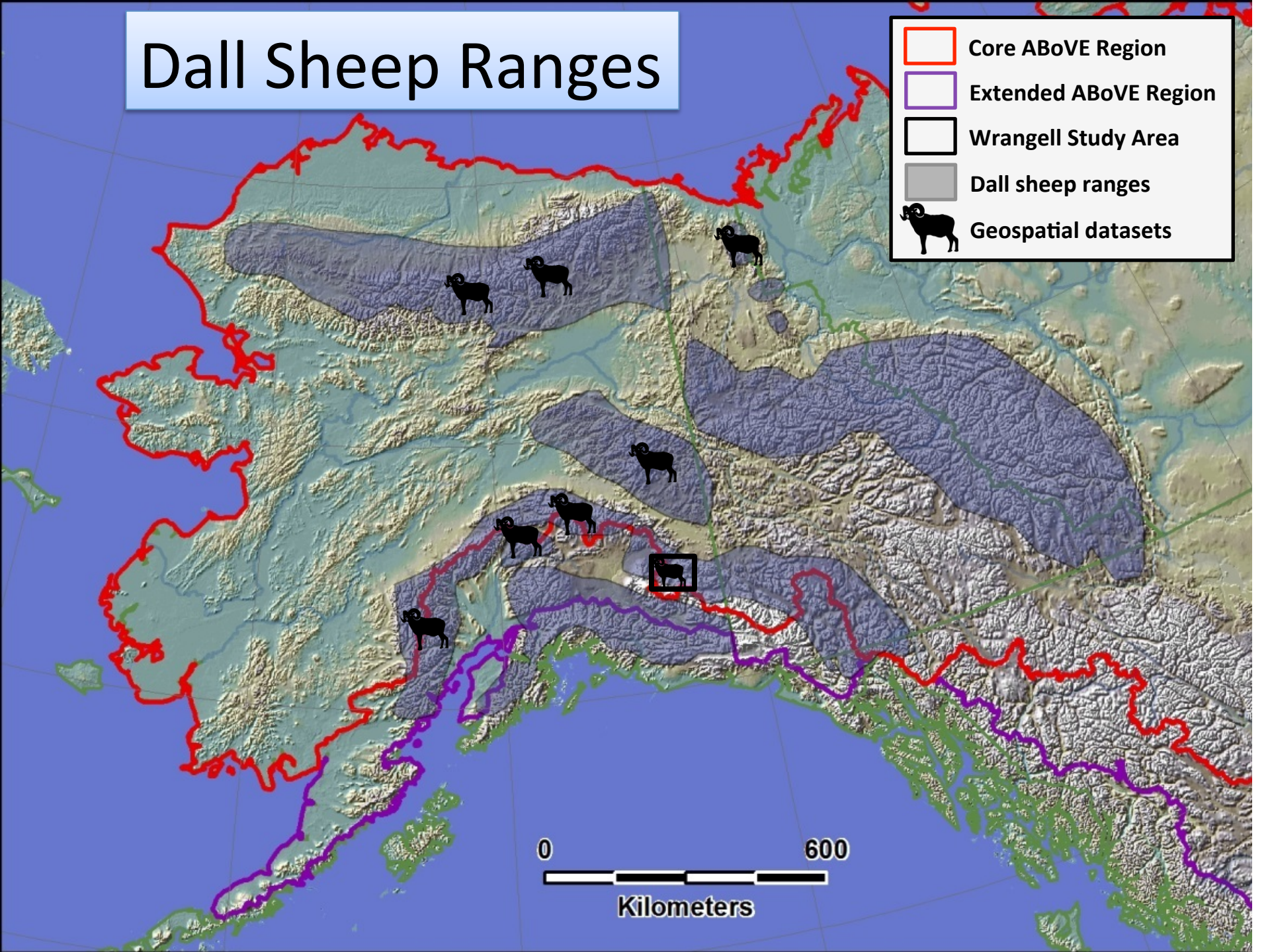


Harvest

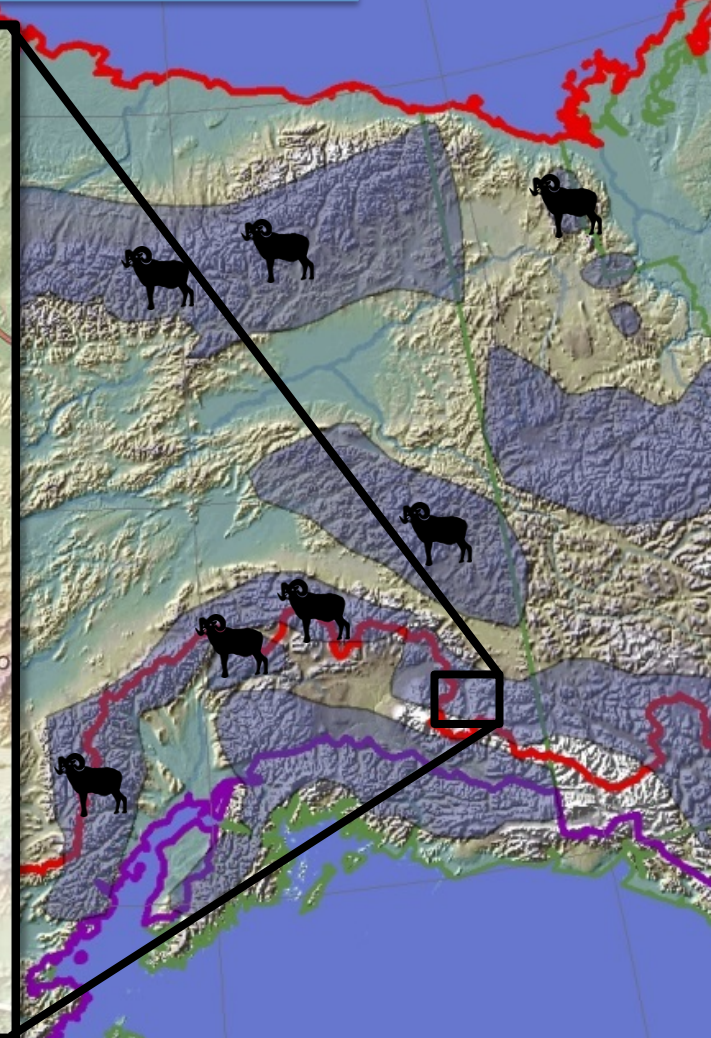
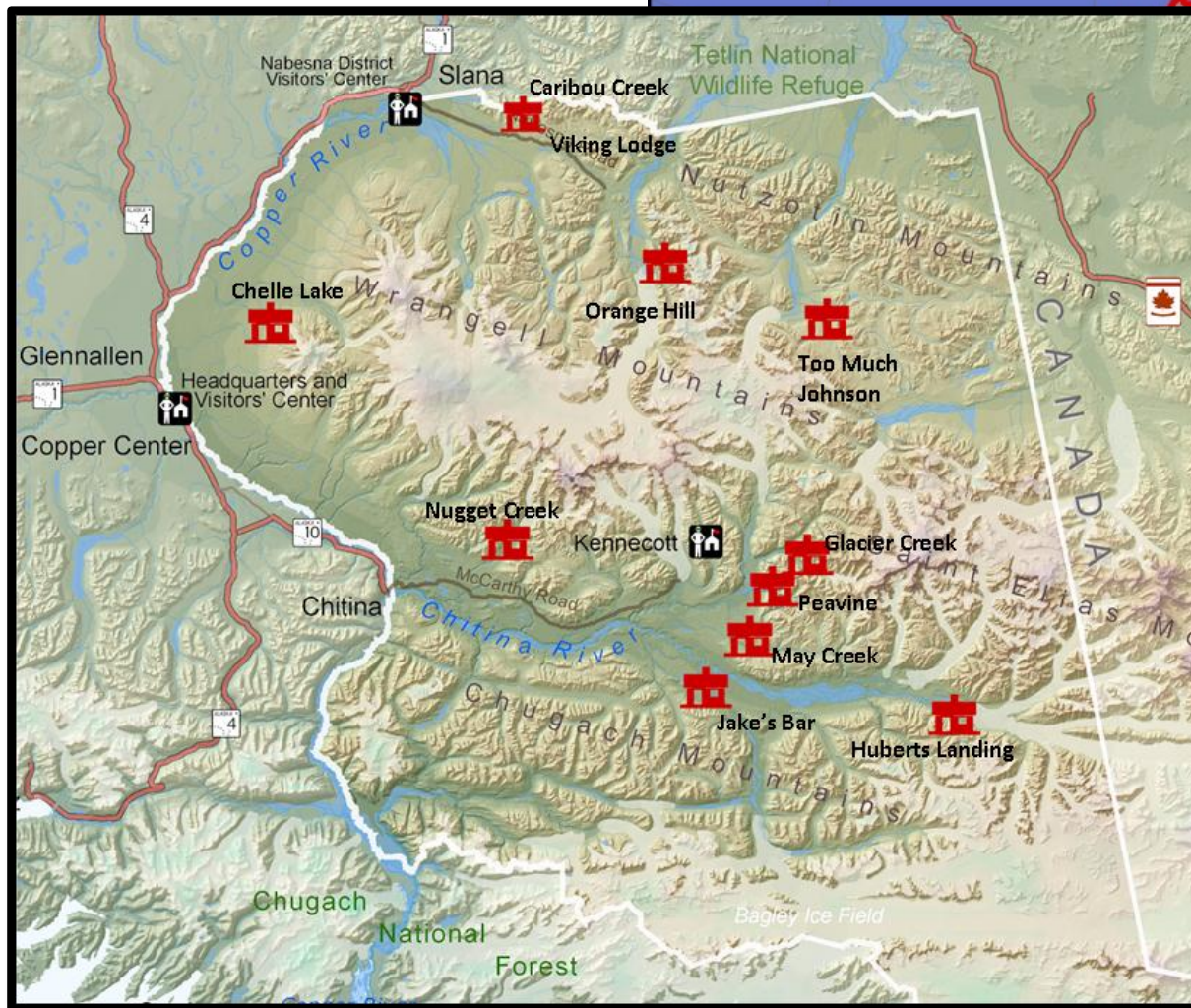


Dall Sheep Ranges

-  Core ABoVE Region
-  Extended ABoVE Region
-  Wrangell Study Area
-  Dall sheep ranges
-  Geospatial datasets



Wrangell St-Elias Study Area



Ground measurements:

Snow



- Years 2 and 3 in Wrangell study area
- 20 snow depth stakes and remote cameras
 - Hourly snow depth measurements, rain vs snow
 - Deployed Sept/Oct, collected March/April
- 1-km snow transects at each of the 20 sites in March/April
 - Snow-Hydro probe, depth ~2m intervals and SWE ~100-m intervals
 - One snow profile pit per transect for snowpack stratigraphy

Ground measurements: Climate

- Climate data from 3 SNOTEL stations
 - Chisana, May Creek, Upper Tsiana



Ground measurements: Dall sheep



- Collaborators Tom Lohuis (ADFG) and Judy Putera (NPS) will GPS collar 60 sheep in year 2
- Locations every 4 hours for 2 years
- Snow measurements in same areas as collared sheep
- Will relate winter movements to snowpack characteristics

Spaceborne Remote Sensing

- Range-wide changes in vegetation and snow
 - DEM
 - MODIS 250m NDVI (MOD13Q1, MYD13Q1), 2000-present
 - Landsat NDVI 1980's-present, Landsat-8 OLI
 - NGA fleet sub-meter imagery of shrub expansion areas
 - MODIS H10V02, H11V02, H13V02, MODSCAG, 2000-present

Spaceborne Remote Sensing

- Snow characteristics in Wrangells
 - MODSCAG
 - Landsat 8
 - DEM
 - GPA
 - Microwave (?)

Airborne Remote Sensing

- No required airborne data
- LiDAR in Wrangells could be useful
- Frequency Modulated Continuous Radar (FMCW) along snow transects in Wrangells would assist with ground-truthing

Modeling Approaches

1. Dall sheep population viability models

$$[\mathbf{f} \downarrow 1 * s \downarrow 1 \ \& \ f \downarrow 2 * s \downarrow 2 \ \& \ f \downarrow 3 * s \downarrow 3 \ \& \ f \downarrow 4 * s \downarrow 4 \\ @s \downarrow 1 \ \& \ 0 \ \& \ 0 \ \& \ 0 \ @0 \ \& \ s \downarrow 2 \ \& \ 0 \ \& \ 0 \ @0 \ \& \ 0 \ \& \ s \downarrow 3 \ \& \\ s \downarrow 4 \] * [\mathbf{n} \downarrow 1 \ @n \downarrow 2 \ @n \downarrow 3 \ @n \downarrow 4 \]$$

- Driver data:
 - Sheep survey and radio-collaring datasets
 - Snow extent and vegetation time series products
 - Climate data
- Format: Content Standard for Digital Geospatial Metadata (CSDM), Federal Geographic Data

Modeling Approaches

2. Resource selection models

- Synoptic model

$$s(x) = f_{10}(x) + \beta * H(x) * f_{10}(x)$$

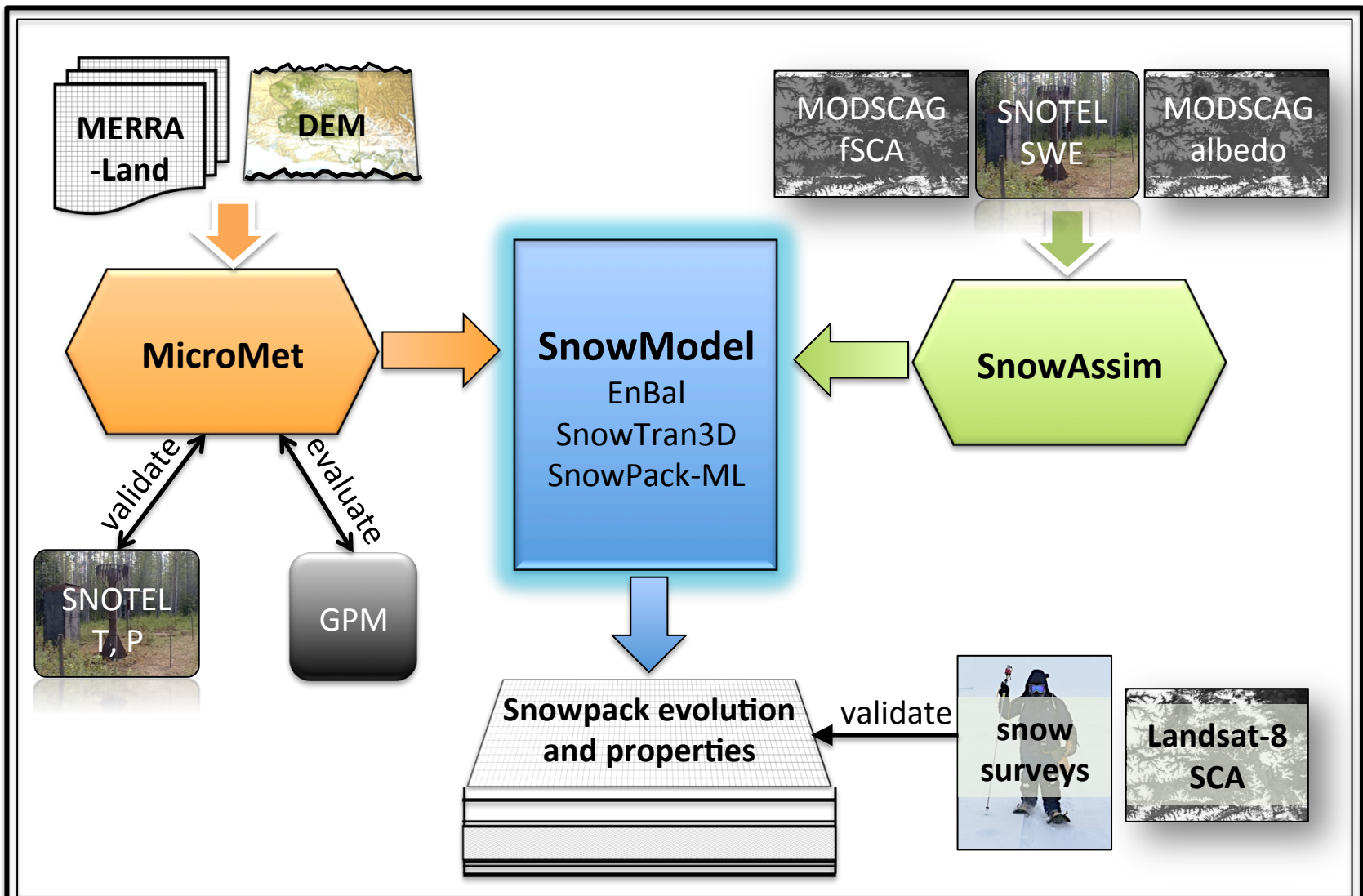
Space use	Selection	Habitat variables
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- Driver data:
 - GPS locations of Dall sheep
 - Vegetation, snow, climate, DEM spatial products
- Format: FGDC CSDM

Modeling Approaches

3. SnowModel, MicroMet, SnowAssim

- Snow evolution model, calculates surface energy exchanges, blowing snow transport, snow layer properties, and snowmelt
- Driver data:
 - MERRA-land climate data
 - MODSCAG snow covered fraction, maybe GPM
 - DEM
 - Land cover (Landsat 8)
- Format: National Snow and Ice Data Center (NSIDC) standard, compatible with FGDC



Representation of SnowModel (Liston & Elder 2006), its related models MicroMet and SnowAssim, and the use of ancillary ground-based, modeled, and remotely sensed data for model input, assimilation, and validation.

Modeling Approaches

4. Sheep harvest models

- Multiple regression models with time lags
- Driver data:
 - Compiled sheep harvest datasets
 - Range-wide vegetation, snow, climate products
- Format: FGDC CSDM

Geospatial Data Products

Data Set	Description & Format	Coverage	Resolution	Time period
Dall sheep geo-location	Lat/longs; Excel, KML	Range-wide	N/A	1997-present
Dall sheep harvest	Counts, Excel	Range-wide	N/A	1950's-present
Dall sheep survey	Counts, Excel	Range-wide	N/A	1950's-present
15-May snow extent	Rasters, GeoTIFF	Range-wide	500-m	2000-present
1-July snow extent	Rasters, GeoTIFF	Range-wide	500-m	2000-present
Max NDVI	Rasters, GeoTIFF	Range-wide	250-m	2000-present
Alpine shrub extent	Rasters, GeoTIFF	Range-wide	30-m	1980s and present
Snow transect data	Snow depth, SWE, and snowpack profile, Excel, KML	Wrangells	N/A	2016-2017
SnowModel output	3-hourly, daily output (snow depth, SWE); GeoTIFF rasters, NetCDF	Wrangells	100-m	2000-present
MicroMet output	3-hourly, daily climate (T, P, RH, solar, LW, wind); NetCDF	Wrangells	100-m	2000-present

Geospatial Data Products

- Stakeholder / user base
 - Wildlife managers (collaborators)
 - Dall sheep working group
 - ABoVE Science Team
 - SnowModel and tutorial on ASC, if interest

Questions?

