Interactions between thresholds and spatial discretizations of snow: lessons-learned from a wolverine habitat assessment

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Abstract

Thresholds are developed for specific uses, influencing results when the same threshold is applied to datasets with different characteristics. **We tested the impact that different spatial discretizations of snow had on estimates of wolverine habitat defined using a snow water equivalent (SWE) threshold (0.20 m) and threshold date (15 May) used by previous habitat assessments**. Annual wolverine habitable area (WHA) was thresholded from a 36-year (1985 – 2020) snow reanalysis performed for: 1) 480 m gridcells, 2) 90 m gridcells, and 3) 480 m gridcells with representations of subgrid snow spatial heterogeneity.

Habitat thresholding

Model, observational, and computational constraints make it difficult to resolve snow water equivalent (SWE) at spatial scales corresponding to Wolverine dens (< 10 m). Past studies have used thresholds to infer wolverine habitat from coarser-resolution SWE products. We ask:

Questions:

1. **How does the spatial discretization of snow influence habitat?**
2. **Is habitat more sensitive to spatial discretizations, or interannual differences in winter climatic conditions?**

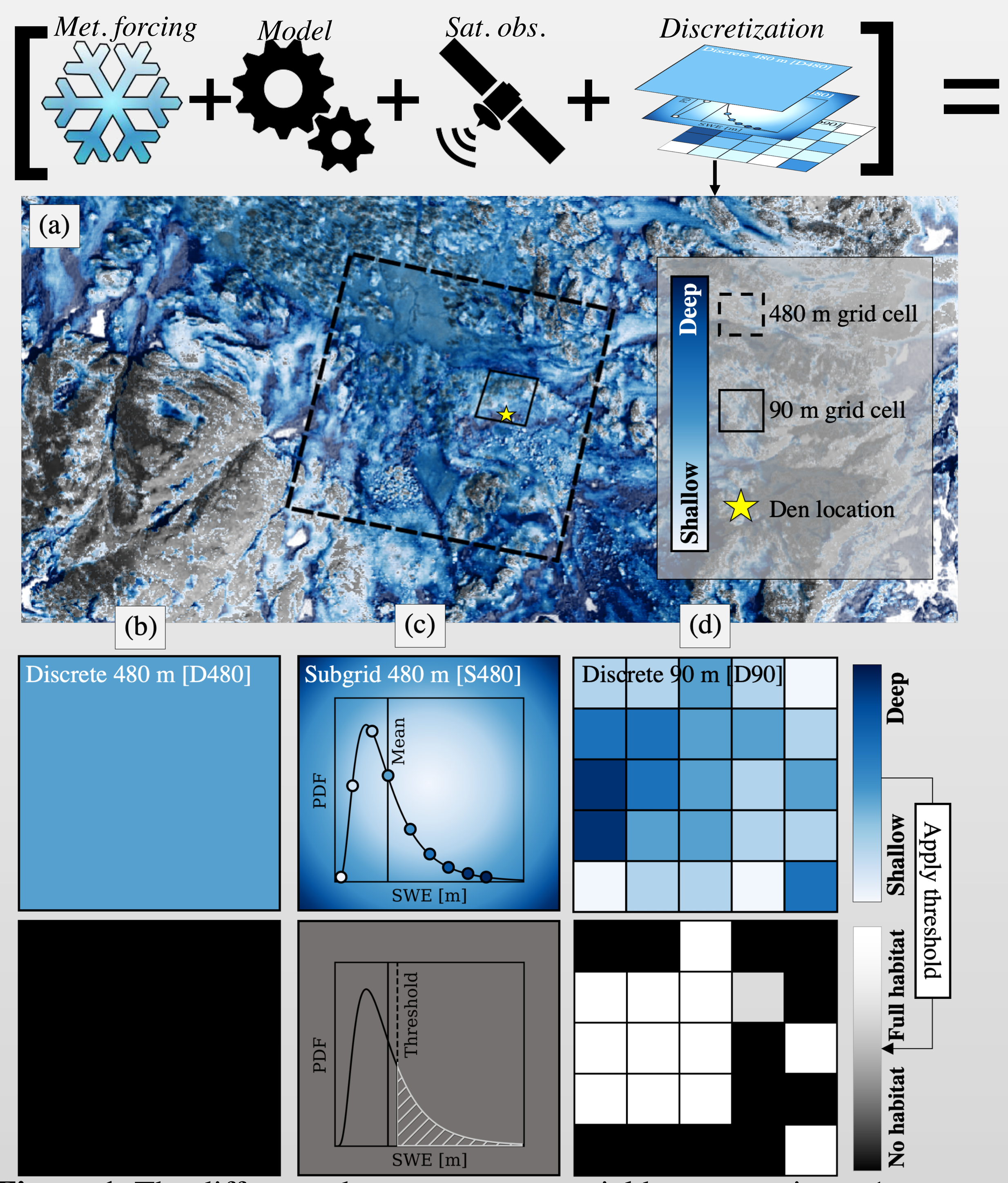


Figure 1. The difference between snow spatial heterogeneity at 1 m resolution (a), and snow discretized using 480 m gridcells (b), 90 m gridcells (d), and 480 m gridcells with implicit representations of subgrid snow heterogeneity (c). Wolverine habitat is defined for each discretization using a threshold (bottom row).

Data and domain

Rocky Mountain National Park, Colorado:

- Location of previous habitat assessment (Barsugli et al., 2020)
- Habitat between 2700 and 3600 m elevation (~75% of region)

Historic snow reanalysis (Margulis et al., 2019)

- MERRA-2 met forcing
- Simplified Simple Biosphere model (SSiB). Ensemble of different:
  - Precipitation multipliers
  - Albedo decays
  - Subgrid snow variabilities
- Landsat observations of fractional snow-covered area (fSCA)

SWE coefficient of correlation of 0.82 versus SNOTEL observations

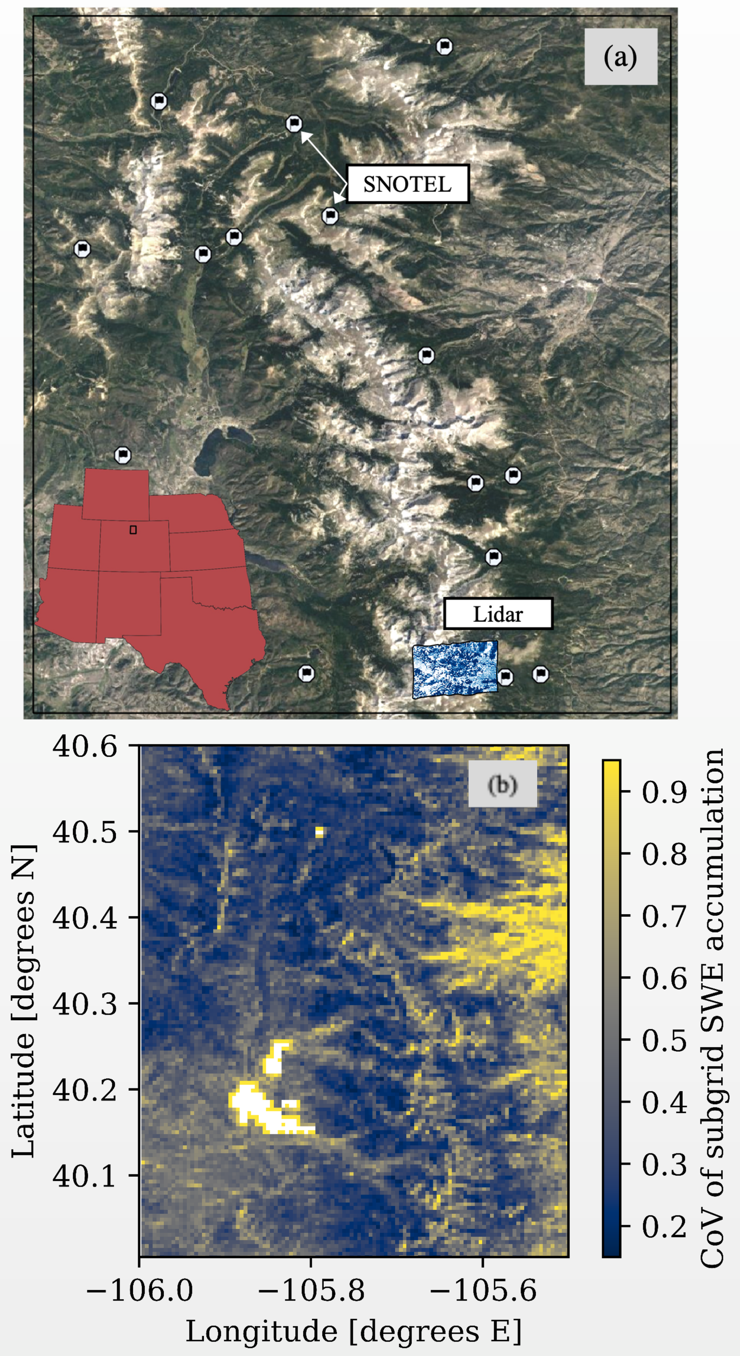


Figure 2. Rocky Mountain National Park (a), and the variability of snow accumulation for 480 m gridcells (b).

Subgrid snow evolution (Liston, 2004)

Accumulation season: temporally-constant CoV

$$f(SWE) = \left(\frac{1}{SWE\,\zeta\sqrt{2\pi}}\right) exp\left[-\frac{1}{2}\left[\frac{ln(SWE) - \lambda}{\zeta}\right]^2\right]$$

Magnitude

Variability (constant)

Variability (constant)

Melt season: spatially-uniform snowmelt

$$f(SWE) = f(SWE, \lambda_{max}) - SWE_{melt}$$

Where/when > 0

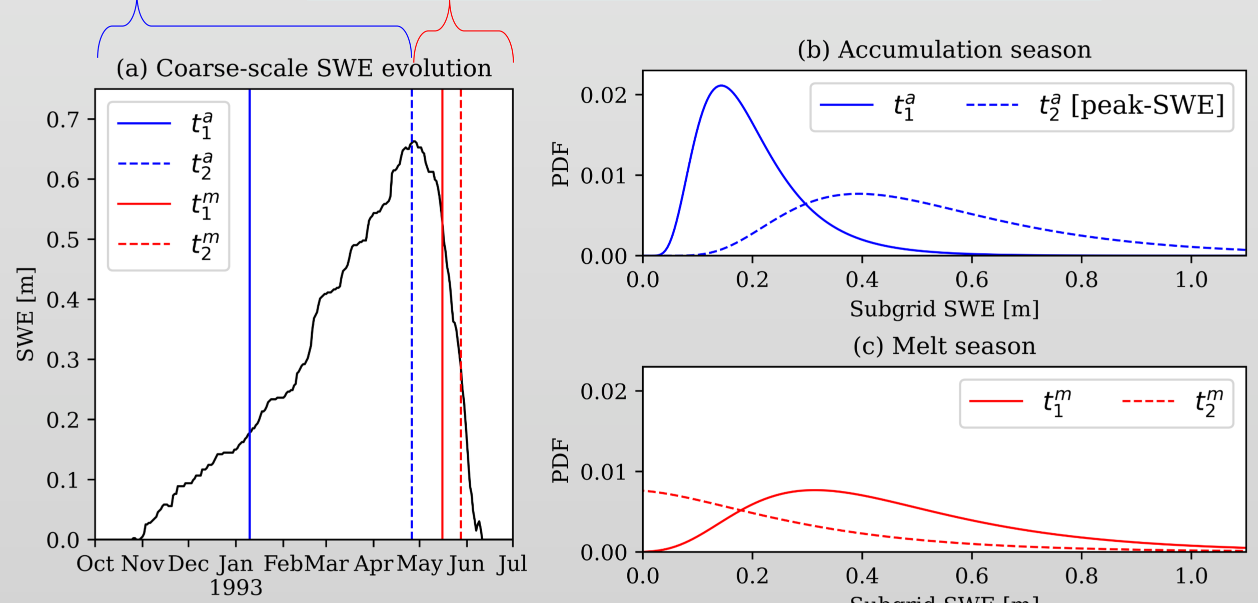
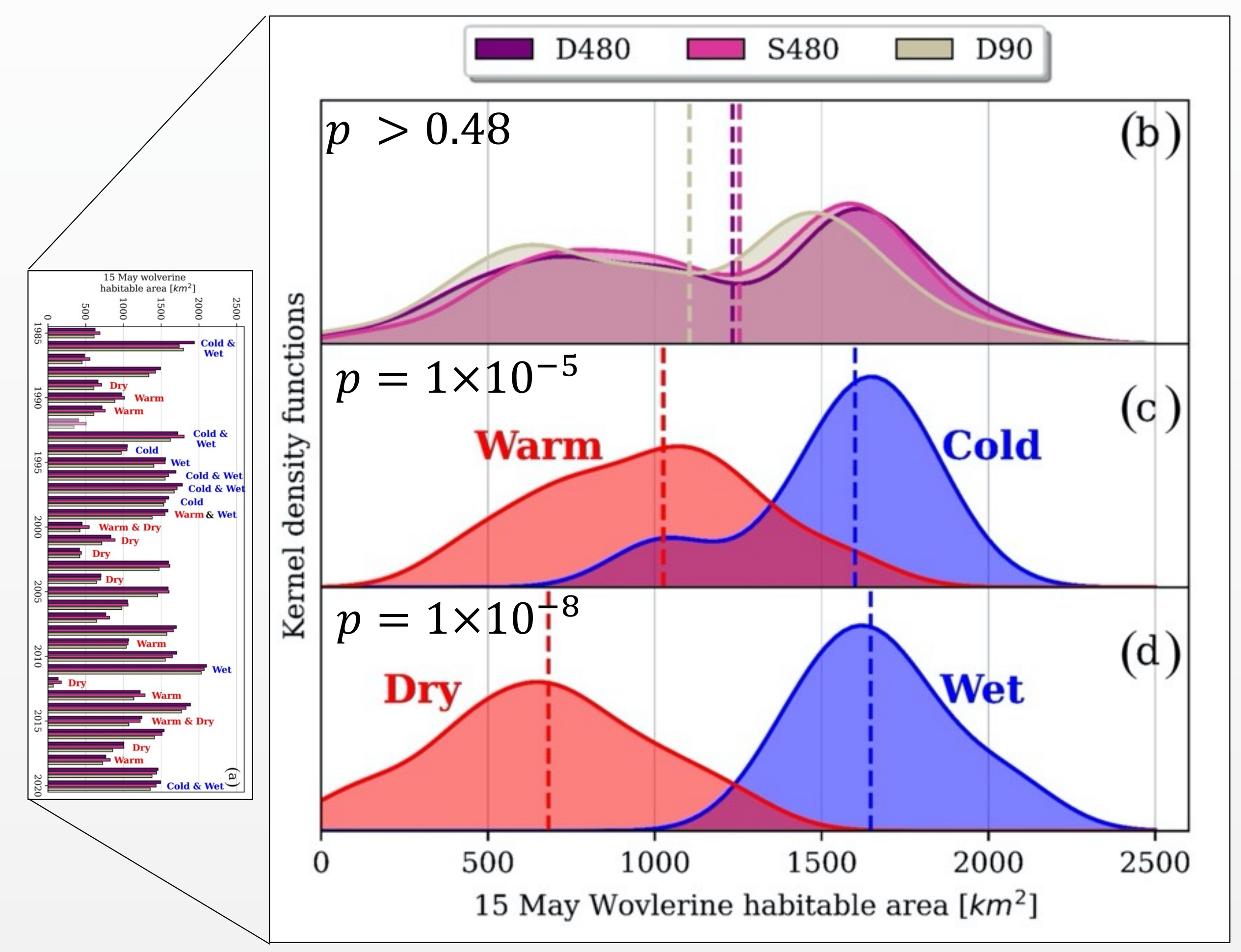


Figure 3. Subgrid variability of SWE accumulation (b) and melt (c) for the mean SWE evolution in panel a, and a CoV of 0.50.

Climate-vs-discretization impacts on habitat

Figure 4. Annual wolverine habitat grouped based on the spatial discretization (b), and years with anomalous temperature (c) and precipitation (d)



- Wolverine habitat was controlled more by winter meteorological conditions (**warm**, **cold**, **dry**, **wet**) than different spatial discretizations (**D480**, **S480**, **D90**)
- Habitat was particularly sensitive to changes in winter snowfall magnitude (**dry** versus **wet**)
- **S480** had less interannual variability than **D480**, and increased habitat by 11 – 30% in low snow years
- **D90** resolved thinner snow deposits in high elevations and reduced habitat by 10%, on average
- Habitat differences were focused at elevations that had SWE near the 0.20 m SWE threshold

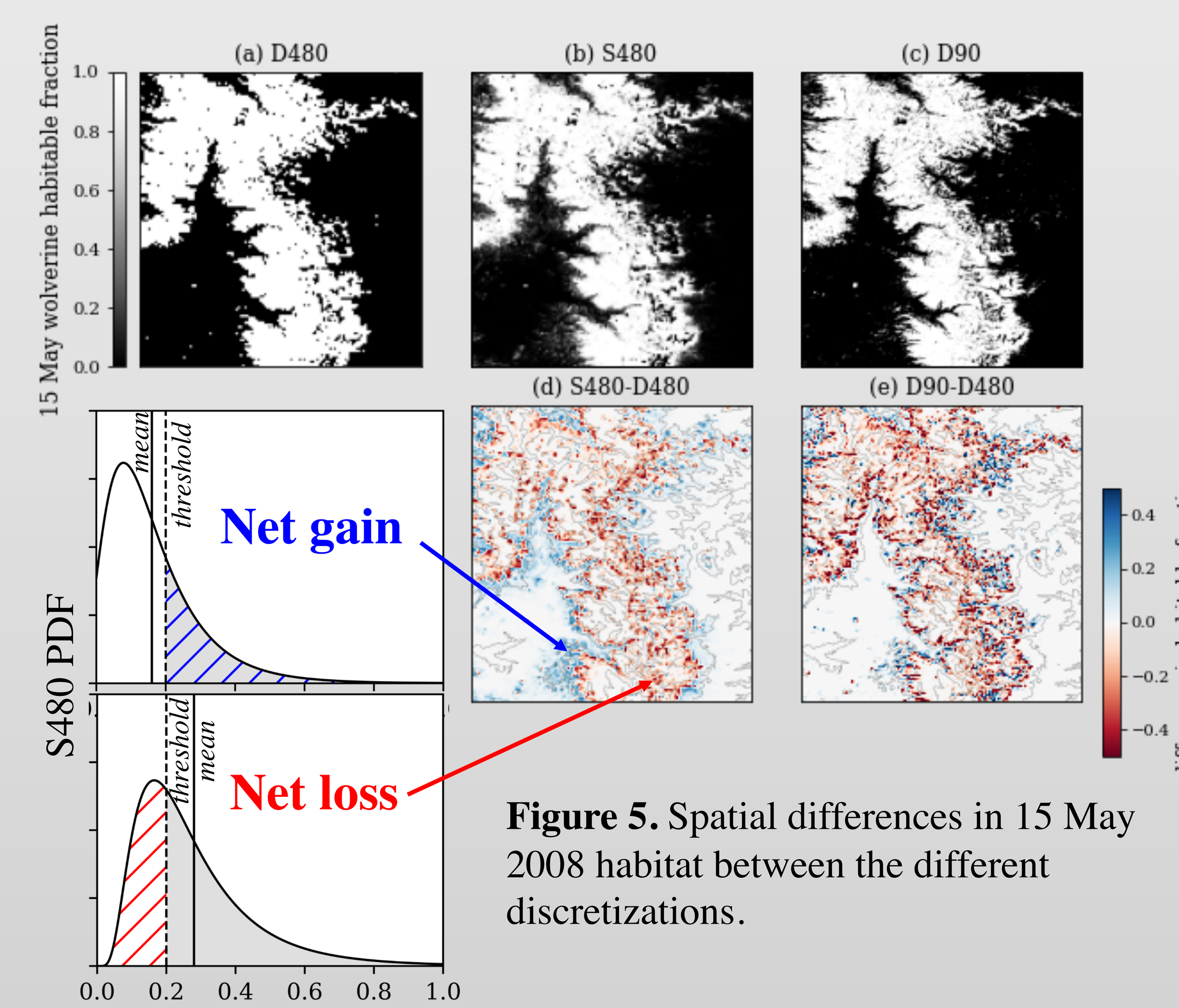
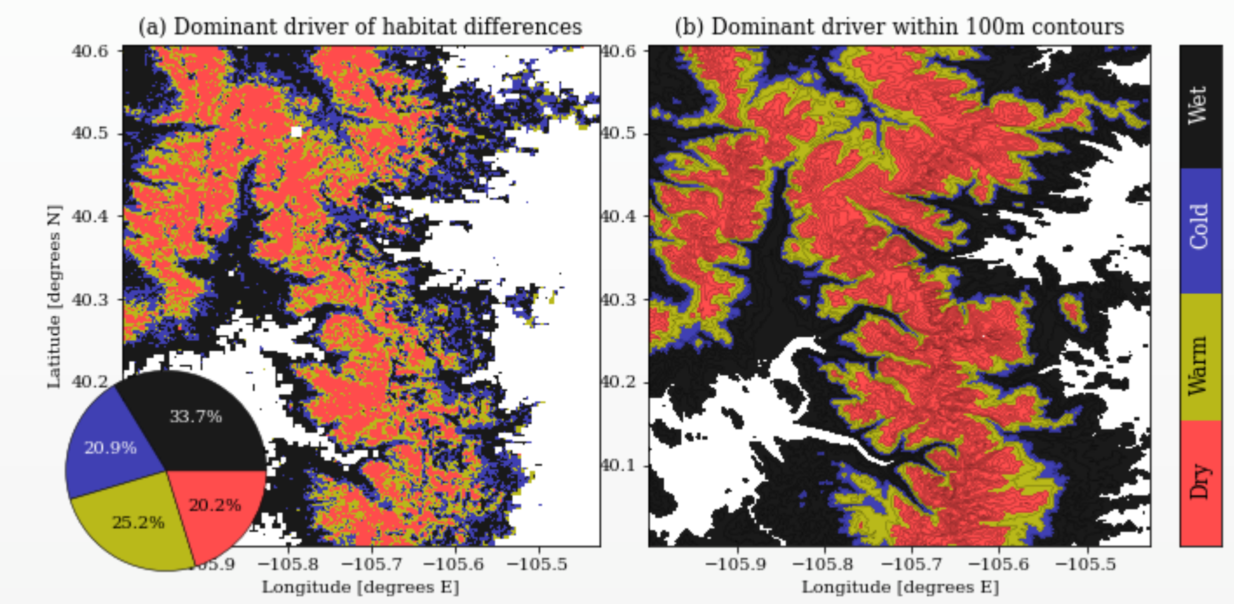


Figure 5. Spatial differences in 15 May 2008 habitat between the different discretizations.

Thresholding sensitivities

Figure 6. The winter climate anomaly most-responsible for differences in habitat between the spatial discretizations at each gridcell (a), and across 100 m elevation bands (b).



- Habitat disagreements were controlled by temperature and precipitation anomalies to similar extents
- Habitat could change by over 80% between different combinations of realistic thresholds
- Most years were more-sensitive to the SWE threshold, but date threshold uncertainties grew in years with spring snowfall
- The S480 discretization had the least amount of threshold sensitivity

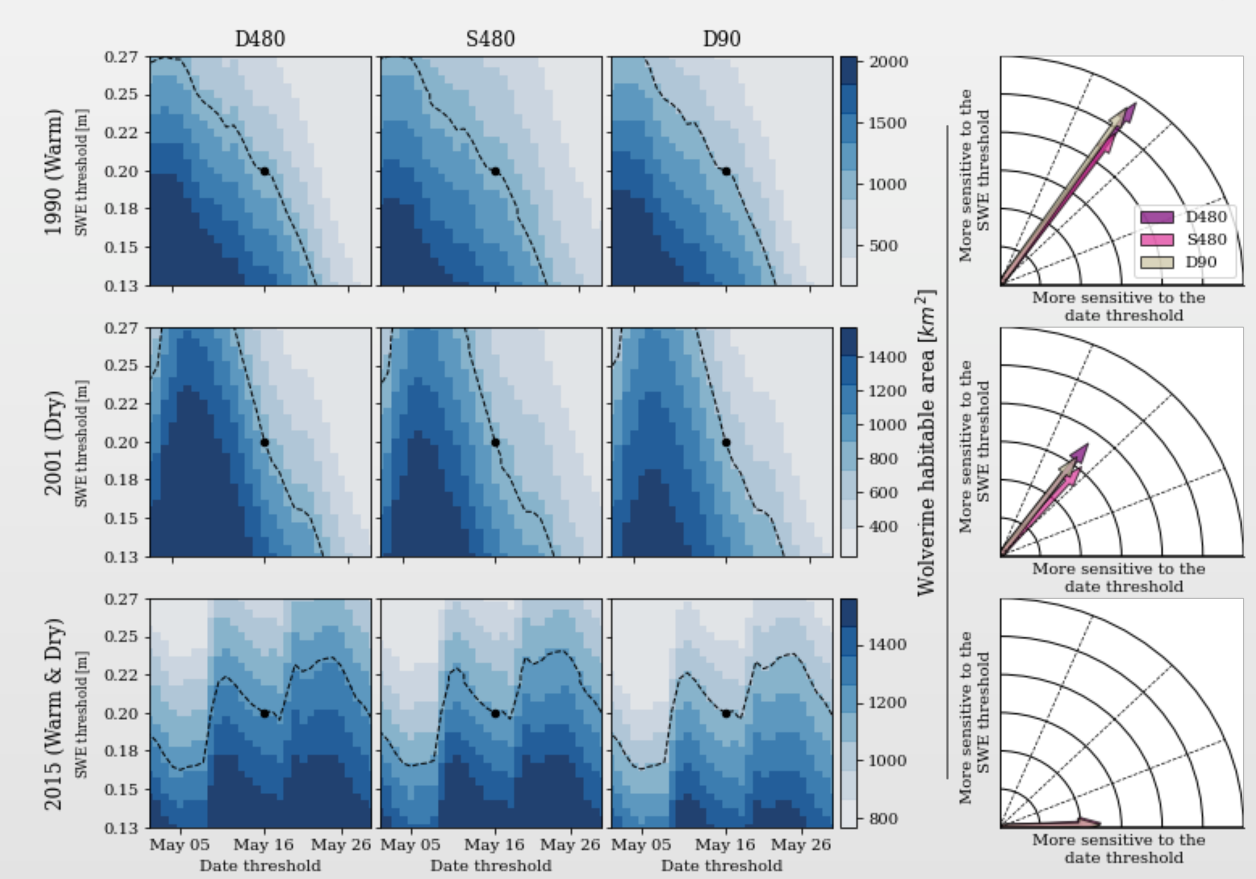


Figure 7. Habitat sensitivity to different SWE and date thresholds for the three discretizations (columns) in three years (rows). Arrows show the magnitude and direction of sensitivities for a given year.

Conclusions

Drawing conclusions from gridded data using a single set of thresholds neglects the uncertainty from 1) differences in heterogeneity at different spatial scales, and 2) uncertainties in the thresholds themselves. Although wolverine habitat was most influenced by winter meteorological conditions, thresholds interacted with three different spatial discretizations of snow in different ways. This was particularly true in low snow years. Studies should include uncertainties from different combinations of discretizations and thresholds. These conclusions are true for not only habitat assessments, but for any studies that threshold environmental data.

References:

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