Laforge, M.P., M. Bonar & E. Vander Wal. Tracking snowmelt to jump the green wave: Phenological drivers of migration in a northern ungulate. Ecology.

**Appendix S3: Calculating fractional snow during migration**

We calculated values of the normalized difference snow index (NDSI) and translated them to the fraction of ground covered by snow (fractional snow cover) to determine fractional snow cover during migration for all herds in our analysis and for individual herds. To do this, we sampled 1000 random points in each of our five replicate herds. We then used Google Earth Engine (Gorelick et al. 2017) to extract the value of the NDSI at each location for early spring to summer (Julian day 45­–200) for each year of our study (2007–2013). We then calculated the day the NDSI first had a negative recorded value (our “day of snowmelt”, see Main Text Methods). We took the peak values of our density distributions of mean days to NDSI = 0 for each individual/year for each herd (surfing indices, see Main Text Methods) and calculated the NDSI value at that day for each herd and for all herds combined. We used the formula presented by Salomonson and Appel (2004) to calculate fractional snow cover from NDSI:

FRA: 0.06 + 1.21 × NDSI [Formula S3]

For our pooled data with all herds, we found that the peak of migration occurred when fractional snow cover was 71% (SD = 25%), see full Results below (Table S1 and Figure S1).

**Literature cited:**

Gorelick, N., M. Hancher, M. Dixon, S. Ilyushchenko, D. Thau, and R. Moore. 2017. Google Earth Engine: Planetary-scale geospatial analysis for everyone. Remote Sensing of Environment 202:18–27.

Salomonson, V. V., and I. Appel. 2004. Estimating fractional snow cover from MODIS using the normalized difference snow index. Remote Sensing of Environment 89:351–360.

Table S1: Summary of normalised difference snow index (NDSI) and fractional snow cover during migration of caribou (*Rangifer tarandus*, *n* = 94) during spring in Newfoundland Canada from 2007–2013. Surfing index represents the day at which density distributions for mean days to snowmelt (first day of year in which the NDSI recorded a negative value) for each individual-year combination were highest for all herds combined and each individual herd (surfing index). Mean NDSI and fractional snow cover values are estimated for those days (rounded to nearest integer value, + SD).

|  |  |  |  |
| --- | --- | --- | --- |
| Herd | Surfing index | Mean NDSI (+ SD) | Mean fractional snow cover (+ SD) |
| All | -7.04 | 0.53 (0.16) | 71% (25%) |
| Buchans | -6.30 | 0.49 (0.16) | 65% (25%) |
| Grey River | -8.39 | 0.54 (0.15) | 72% (24%) |
| Lapoile | -17.23 | 0.67 (0.15) | 88% (24%) |
| Middle Ridge | 1.41 | -0.15 (-0.15) | 0% (0%) |
| Topsails | -3.08 | 0.38 (0.20) | 52% (30%) |

A close up of a map

Description automatically generated

Figure S1: Total fractional snow cover through time as a function of number of days until the first recorded negative normalized difference vegetation index (NDSI) value at each location in caribou (*Rangifer tarandus*) ranges on the island of Newfoundland, 2007–2013. A total of 1000 locations were sampled in each herd and the NDSI extracted for each location. Thick black lines represent data for all herds combined, colors represent individual herds. Vertical lines represent peak migration timing for all herds/each herd (surfing indices, see Main Text Methods). Fractional snow cover for each herd during the peak of migration occurs at the intersection of lines of the same color. Dashed black lines represent the standard deviation for all herds combined (standard deviations for each herd separately not shown). Note, all values that would result in a fractional snow cover value outside the range of 0–1 were set to 0 or 1.