

Shrubification in the Western Arctic and its Effects on the Porcupine Caribou Herd Habitat

Background and rationale:

The Arctic has been warming more than twice as fast as the global average: since the late 19th century, the Earth has warmed by approximately 0.8°C, while the Arctic has warmed by 2°C to 3°C (Post et al., 2019; IPCC, 2013). Increasing temperatures have altered snow regimes and extended the growing season (Bjorkman et al., 2020), advancing plant spring phenology. Concurrent with Arctic warming, deciduous shrubs have expanded in cover and outcompeted other plant groups such as mosses and lichens (Elmendorf et al., 2012). Changes in vegetation in turn influence the abundance and distribution of Arctic herbivores. Caribous (*Rangifer tarandus*) are among the most abundant long-range migratory herbivores in the Northern Hemisphere (Mallory & Boyce, 2017). Distributed across the U.S-Canadian border, the Porcupine Caribou Herd (PCH) is one of the largest herds in North America (Severson et al., 2021). Arctic greening could be deteriorating pasture quality, with shrubs outcompeting lichen and mosses - caribou's preferred diet in winter and spring - resulting in potential declines in caribou populations (Fauchald et al., 2017). Changes in plant phenology affect PCH spatial distribution, with caribou tracking protein-rich vegetation in early growth stages and predominantly using Alaskan range in years of accelerated phenology (Severson et al., 2021). Understanding how the PCH distribution may respond to future shrubification is crucial to inform habitat conservation commitments across the Alaska-Yukon border and to ensure the subsistence of Indigenous communities (Severson et al., 2021).

Research questions:

- Which areas within the PCH range are most vulnerable to shrubification?
- How will changes in vegetation influence the nutritional health of the PCH?
- Will shrubification affect the PCH future migratory behaviour?

Hypotheses:

- Warmer temperatures could enhance soil microbial activities that supply nutrients for shrub uptake (Myers-Smith et al., 2011) facilitating shrub growth in particular regions of the PCH summer range.

H1: Shrub cover will be greater in warmer and wetter areas of the PCH summer range.

H0: Shrub cover will not be associated with variation in temperature and moisture in the PCH summer range.

- Shrubs could outcompete lichens and mosses, deteriorating nutritional health of the PCH since shrubs have strong anti-browsing defences (toxins) (Fauchald et al., 2017).

H1: Increased shrub cover will be associated with decreased lichens and mosses cover and thus decreased forage quality.

H0: Increased shrub cover will not affect lichens and mosses cover, with forage quality remaining unaffected.

- In spring and early summer, caribou will seek out vegetation in early phenological stages, with higher protein (Severson et al., 2021). Advances in plant phenology and shrubification will increase use of ranges westward and northward (Alaskan coastal plain, with mottled snow protecting from predation and high quality plants early emergence) and decrease use of the eastern range (Yukon) (Severson et al., 2021).

H1: Increased shrub cover will be associated with increased use of ranges westward and northward and decreased use of the eastern range.

H0: Increased shrub cover will not affect range use.

Methods:

1. Map shrub cover (aboveground biomass) within the summer (and winter) range of the PCH, using total caribou annual range data 1983 - 2001 (U.S Department of the Interior, from Griffith et al. 2002) and shrub map of North Slope of Alaska 2007-2016 (Berner et al., Arctic Data Centre, 2021). Crop shrub map to caribou range to know where shrubs are within the range.
2. Map out changes in NDVI (or other vegetation indices) within the PCH range, using Landsat NDVI data over time (Berner et al., Nature Communications, 2020).
3. Test whether increasing spectral greenness corresponds with shrub cover.
4. Compile forage quality, preferred summer forage information and nutritional health of caribou from the literature (pers. comm. Libby Ehlers, 2021)
5. Analyse vegetation change from long-term plot-based vegetation monitoring in or near the PCH summer range (Arctic Vegetation Archive).
6. Map out areas within the PCH range that are most “vulnerable” to shrubification and infer how that might change diet with future migration patterns.

Expected results:

- Shrubbification will be happening mainly at wetter and warmer areas of the PCH summer range (Myers-Smith et al., 2011).
- Shrubs will outcompete caribou’s preferred forage elements (lichen, moss, forbs) undermining forage quality (Bernes et al., 2015) and caribou nutritional health.
- PCH will make temporal and spatial adjustments to adapt to future changes in phenology and shrubification. PCH migration between summer and winter ranges will happen earlier, (e.g. barren ground caribou changed migration and calving dates by up to 0.5 days/year (Libby Ehlers, 2021)) and the Alaskan coastal plain will become an increasingly important habitat (Severson et al., 2021).

Reference list

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