Brief Communication

Long-term patterns of abiotic drivers of mosquito activity within summer ranges of Northern Alaska caribou herds (1979–2009)

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Introduction

Harassment by mosquitoes is an important factor influencing caribou (*Rangifer tarandus)* activity and movement patterns during summer (Kelsall, 1968; White *et al.,* 1975; Russell *et al.,* 1993). Incidence of mosquito activity, and consequently harassment to caribou is spatially and temporally dynamic in response to temperature and wind (Thomson, 1971; White *et al.,* 1975; Dau, 1986). Our knowledge pertaining to mosquito harassment for northern Alaskan herds is limited to the studies done within the ranges of Central Arctic herd from 1973–74 (White *et al.,* 1975) and 1982-83 (Dau, 1986), and the Porcupine herd from 1984–85 (Nixon, 1991). These assessments were done more than quarter of a century ago in only a small portion of these herds' summer ranges. Consequently, those results may not be representative of spatial conditions across entire summer ranges or long-term inter-annual variability, as well as the present conditions. Additionally, there are concerns regarding how warming summer temperatures (Wendler *et al.,* 2010) might influence the conditions conducive for potential mosquito activity that results in harassment to caribou within the summer ranges. Therefore, long-term estimates of mosquito activity that are spatially represented within the entire summer range of a herd are warranted. Objectives of this study were to (1) assess changes in potential mosquito activity in response to climate variability over space and time in northern Alaska, and (2) compare projected intensity of potential mosquito activity across the four Alaskan barren-ground caribou herds of Arctic Alaska.

Table 1. Algorithm for computing Mosquito Activity Index (MAI) are adapted from Russell *et al.* (1993). MAI is computed for every 3-hourly period using instantaneous surface air temperature and wind speed data from the North American Regional Reanalysis (NARR) gridded climate dataset using this algorithm.

Mosquito Activity Index MAI = TI × WI,
Where TI is Temperature Index (range between min 0 – max 1),
and WI is Wind Index (range between min 0 – max 1)

If instantaneous temperature T > 18° C	➔ TI = 1
If T < 6° C	➔ TI = 0
If 6° C ≥ T > 18° C	➔ TI = 1 – ((18-T)/ 13)
If instantaneous wind speed W > 6 m/s	➔ WI = 0
If W ≤ 6 m/s	➔ WI = (6-W)/6

Methods

We used the North American Regional Reanalysis data (NARR, Mesinger *et al.,* 2004), a long-term, gridded (0.33°latitude/longitude) climate dataset to estimate patterns in abiotic drivers of mosquito activity over space and time in northern Alaska. NARR surface air temperature and wind speed data were used to estimate potential mosquito activity within the summer ranges of four caribou herds: Western Arctic herd (WAH), Teshekpuk caribou herd (TCH), Central Arctic herd (CAH), and Porcupine caribou herd (PCH).

We computed a "Mosquito Activity Index (MAI)", a theoretical measure of mosquito harassment potential based on instantaneous air temperature and wind speed (Russell *et al.,* 1993; Table 1). We applied this relationship between mosquito activity and its abiotic drivers to every grid cell in the study region using 3-hour climate data, for every day of an a priori defined season (*i.e.*, 1 June to 31 August) for every year over our 31-year study period (1979–2009) to compute daily MAI for each grid. We used the software GrADS Ver 2.0 (Doty, 2011) to visualize and manipulate the climate dataset. The MAI is represented on a scale of zero to one, where zero is absence of mosquito activity and one is the highest potential for mosquito activity if mosquitoes are present.

To meet the first objective, we computed spatially explicit, long-term trends in MAI for northern Alaska. To address the second objective, we averaged the MAI over all grids within the entire summer range of each herd, and within each season (1 June to 31 August) for every year to compute an annual mean, and we compared the annual patterns of MAI between the herds.
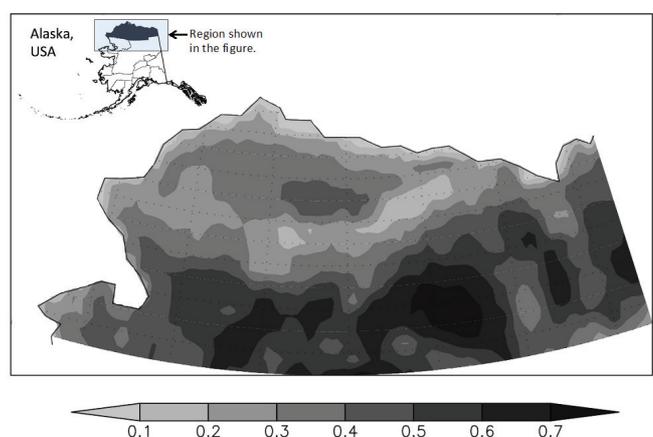

Fig. 1. Average annual MAI for northern Alaska for the period 1979–2009 showing regions of high (dark) and low (light) potential mosquito activity.
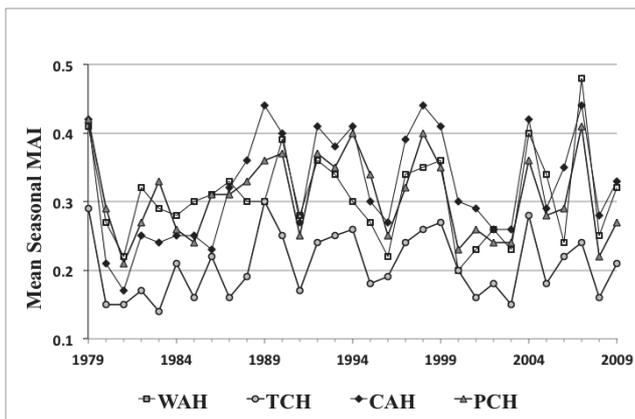
Fig. 2. Mean annual mosquito activity (daily MAI averaged for every season over 92 days, and entire summer range) from 1979–2009 for Western Arctic herd (WAH), Teshekpuk lake caribou herd (TCH), Central Arctic herd (CAH), and Porcupine caribou herd (PCH).

Results

The long-term average of daily MAIs depicts the spatial patterns of potential mosquito activity, over the 31-year period in Northern Alaska (Fig. 1), and highlights the regions of average high and low MAI during 1979–2009. Overall the coastal regions experienced the lowest MAI while regions south of the Brooks Range experienced relatively higher MAI. Comparison of MAI among herds' summer ranges shows similar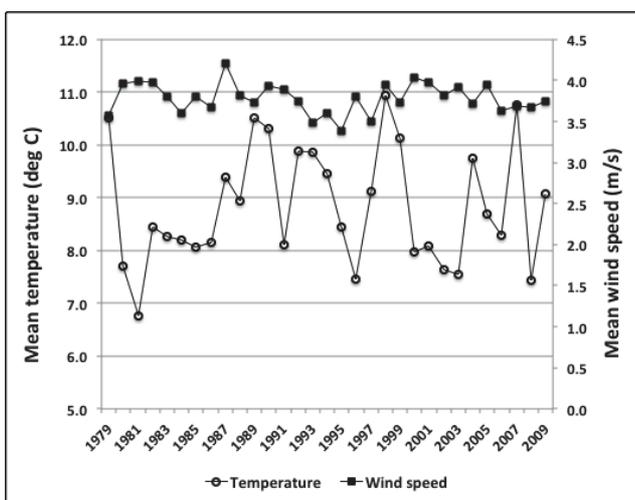 temporal patterns in peaks and troughs in mean annual MAIs, although differing in magnitude (Fig. 2). The lowest 31-year average annual MAI was for the TCH (0.21 ± SD 0.04); followed by the WAH (0.31 ± 0.06) and PCH (0.31 ± 0.06); and CAH (0.33 ± 0.08). The lower MAI values for the TCH are primarily attributed to consistently higher winds in the summer range for this herd. The highest range of inter-annual variability in MAI was for the CAH.

Mean summer temperature (June-July-August) was more variable than mean summer wind speed among years (Fig. 3). Changes in temperature contributed most to overall inter-annual variability in the magnitude of MAI for all four herds from 1979–2009. Variability in wind was more related to the spatial aspects such as distance from the coast and topography, and at any given location wind patterns were more constant than temperature over the entire analysis period. In our analysis the differences in spatial wind patterns drove the differences in magnitude of MAI among the four herds for any given year.

Discussion

Our analysis indicated a marked variability in mean seasonal MAI among the 31 years and the relative magnitude of this variability was consistent among the four herds. Overall the TCH summer range hosted the least conducive weather conditions for mosquito activity. This was due to coastal proximity, where cooler temperatures and higher winds prevailed. While TCH and CAH summer ranges are very similar in characteristics, with proximity to coast and absence of upland habitats, the wind patterns within the CAH range experienced higher seasonal variability; hence the difference in overall MAI values for the two herds (Fig. 2).

Although the MAI estimates were based on a theoretical model derived from empirical relationship between abiotic drivers of mosquito activity (Russell *et al.*, 1993), the potential "hot

Fig. 3. Mean temperature and mean wind speed for the period 1 June to 31 August for the study region (1979–2009).

spots of mosquito activity" (*i.e.*, the areas showing highest mean MAI in the summer ranges for 1979–2009), and the potential "mosquito relief areas" (*i.e.*, areas of low MAI that we identified), warrant further verification with field data. Our analysis demonstrates a novel way for using climatology datasets to model long-term spatial and temporal distribution of potential mosquito harassment for caribou. We suggest these results could be useful in understanding seasonal distribution and movement of herds, implications for energetics and body condition from year to year, and comparison of relative effects on different herds.

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