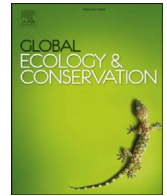




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Declining recruitment and mass of Swedish moose calves linked to hot, dry springs and snowy winters



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ABSTRACT

As global temperatures continue to rise, increases in the frequency and intensity of climatic extremes will likely outpace average temperature increases, and may have outsized impacts on biological populations. Moose (*Alces alces*) are adapted to cold weather and populations are declining at the southern edge of the species' range. Moose therefore make a suitable case study to examine the relationship between population performance and both climatic averages and the frequency of rare, intense climatic events. More than twenty years of slaughter weights and moose observations collected by hunting teams across all of Sweden show that early calf recruitment has declined throughout Sweden and calf mass has also declined, particularly in central and southern Sweden. Spring weather affected mean calf mass, which declined with higher average temperatures, more frequent very hot days (days in the 95th percentile for maximum temperature) and less precipitation during this season, though in the case of hot days only when high temperatures coincided with low rainfall. This supports previous observations of moose sensitivity to both direct heat stress and the negative impacts of hot, dry spring weather on forage quality. Recruitment was similarly impacted, and the interaction between the previous year's temperature and precipitation supports a lagged effect of weather on recruitment, via female condition. Finally, cold winter temperatures and deeper snow were associated with reduced calf mass during the following autumn, while deeper snow was additionally linked to fewer calves per female. Our results suggest that similar patterns may exist for averages and the frequency of extreme values, but it is important to examine both in order to improve biological relevance. The significant and ongoing declines in calf mass in southern populations and calf recruitment throughout Sweden should serve as an early warning that Eurasian moose may suffer from climate change in similar ways to North American moose. We discuss conservation management strategies, both in terms of harvest as well as landscape management, that may help mitigate the observed patterns.

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