Early Summer Precipitation and Temperature Associated with Mountain Goat Declines in Glacier National Park

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ABSTRACT: A shifting climate poses threats to alpine-adapted species including mountain goats. We used a 12 year citizen science dataset and a Bayesian N-mixture model to estimate population trend and factors associated with trend of mountain goats in Glacier National Park. Median goats per site declined by 45% (95% CRI = 32%, 57%) from 77.8 (95% CRI = 64.4, 95.1) in 2008 to 42.3 (95%CRI = 34.3, 52.2) in 2019, with consistent declines from 2008 until 2015, when the number of estimated goats stabilized. The >30% decline over only 2 generations exceeds IUCN criteria for classifying a population as vulnerable. Climate variables had the greatest association with population growth rate, particularly precipitation between May 15 and June 15 of the previous summer, the neonatal period. Greater growth occurred with greater snow water equivalent, mean winter temperature, early summer temperature and early summer precipitation. In addition, the proportion of permanent snow and glaciers and the presence of natural mineral licks strongly influenced initial abundance of goats. We are not able to determine the relative contribution of vital rates to this apparent decline. However, the results are consistent with the pattern of kid to nanny ratios across time. Our results also suggest ways to improve detection rates during visual goat surveys, which is important for precision of estimates. Retention of observers with experience, consistent use of a spotting scope, and conducting surveys at lower temperatures and earlier dates could all increase detection for the citizen science program. This will be particularly important given the lower number of goats currently observed in the park. Research to estimate the population size, assess population fluctuations, evaluate genetic structure, assess changing habitat, human recreation levels and forage, and to forward project climate effects on persistence will be crucial to understanding the context of these results and conserving this iconic, meta-population at the southern edge of the distribution of native mountain goats.

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