

The Effect of Large Animal Removal or Protection under the Future of Climate Change

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10 S1 The Models used in this study

The Madingley model (Harfoot et al., 2014), models animals as cohorts; different groups of similar individuals that share ecological properties such as feeding type, reproduction strategy and thermoregulation. These properties are defined by the cohorts “animal functional type” (AFT). Ecological processes encompass metabolism, feeding (herbivory and predation), growth, reproduction, migration and mortality and are applied to the cohorts, rather than individual animals to minimize
15 computational load. Within a cohort, all individuals are expected to have the same age, individual body mass, stored reproductive body mass, and an adult body mass threshold.

The dynamic global vegetation model LPJ-GUESS (Smith et al., 2014) simulates plants as cohorts of different “plant functional types” (PFTs) that share key ecological traits, which are defined by bioclimatic preferences, lifeforms, photosynthetic pathways, shade-tolerance and phenology. Such cohorts compete for water, nutrients, light and space on patches of land that
20 are prone to statistical disturbance events. In this study, 30 patches were averaged within each grid cell to ensure stochastic stability. A list of all simulated plant functional types can be found in Krause et al. (2025), together with a more detailed description of both models and the coupling.

Notably, Madingley represents leaf biomass as wet matter (kg km^{-2}), while LPJ-GUESS expresses leaf biomass as carbon mass (kg C km^{-2}). Since leaf carbon mass is directly proportional to leaf wet matter, the change rates of both measures are
25 identical. For simplicity, we are referring to leaf biomass in the manuscript since we only present proportional changes.

S2 Animal Removal Methodology

As stated earlier, in the Madingley model, each individual has an adult body mass threshold, that distinguishes juveniles from adult cohorts. Once a cohort is classified as an adult, it begins acquiring biomass for reproduction. Upon the birth of a juvenile
30 cohort, that new cohort’s adult body mass trait is determined based on their parent’s adult body mass trait. When removing

cohorts from the simulation, we use the adult body mass trait as the selection criterion. This ensures that no juveniles are kept in the simulation that would eventually grow to an adult body mass that surpass the defined removal threshold. In Madingley, cohorts' adult body mass can also naturally evolve toward heavier weights through iterative increases across generations. To prevent the reappearance of large animals throughout the simulation, it is essential to remove cohorts consecutively. Therefore, we removed herbivores or carnivores annually. Specifically, if a cohort's adult body mass is found to exceed a set removal threshold at the end of a year, its abundance is set to 0, effectively removing it from the simulation. The biomass of such removed cohorts is discarded and has no influence on the ongoing simulation. Instabilities in the bidirectional coupled model system are avoided by implementing the removal gradually, starting with adults heavier than 41 kg. Every following year, the removal threshold is lowered by 1 kg until the lower limit of 21 kg is reached. This lower limit is based on Hoeks et al. (2020) who defined this threshold based on Malhi et al. (2016).

S3 Updated Carnivory Process

Hoeks et al. (2020), on which we base the experiment presented in this study, changed the preferred predator-prey body mass ratio from 0.1 to 1.0 for predators with an adult body mass heavier than 21 kg, based on the allometric relationships described in Carbone et al. (1999). However, this results in a step change such that carnivores weighing 20.9 kg prey on animals weighing 2.09 kg, while carnivores weighing 21 kg prefer prey that also weighs 21 kg. This creates a predation gap between 2.09 and 21kg, and consequently, an overproportional reproduction success rates of cohorts within this size category (see Figure 1). The juveniles of large carnivores play a unique role here; they have exclusive access to prey within the size range of the predation gap. However, their number is small compared to the overall carnivore population, so they cannot effectively fill the gap. To address this issue, we implemented a linear increase of carnivores' optimal prey body mass ratio from 0.1 at 2 kg to 1.0 at 21 kg (Figure 1). Without this modification, the removal large carnivores (>21 kg) would lift carnivory pressure of all cohorts larger than 2kg instead of 21kg.

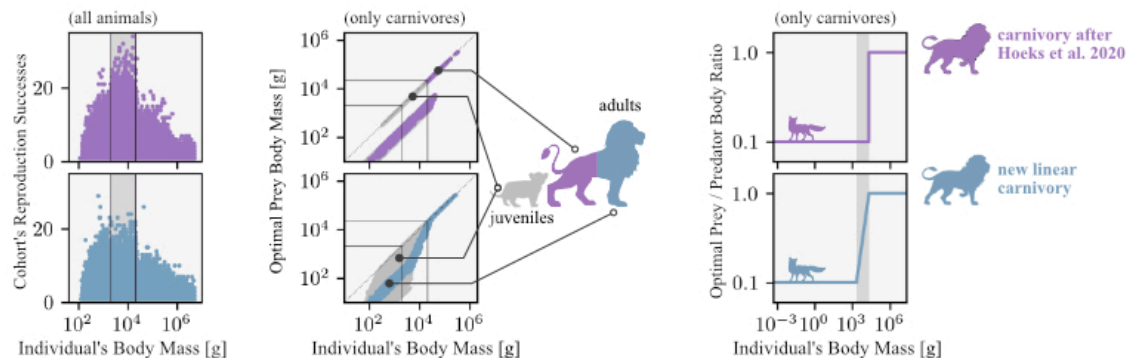


Figure 1: The implementation of a linear increase in optimal predator-prey body mass ratio. Throughout the figure, violet indicates data from a simulation with carnivory following (Hoeks et al. 2020), while blue indicates data from a simulation with the updated carnivory process. The greyed-out areas in the left and right panels indicate the size range of the identified predation gap. The left panel shows the number of reproductive successes of all endothermic cohorts alive at the end of the simulation. The middle panel shows carnivores' optimal prey body mass plotted against their body mass (juveniles are plotted in grey). The right panel shows the sharp transition of the carnivore's optimal predator-prey ratio from 0.1 to 1.0 after (Hoeks et al. 2020) (top) and the new linear transition (bottom).

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