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Abstract Book

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Linking movement ecology and zoogeochemistry: red deer as drivers of nutrient redistribution in the Alps

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Animals function as dynamic vectors in biogeochemical cycles, actively transporting nutrients across ecosystems. However, traditional zoogeochemical models frequently oversimplify this role, treating animal inputs as static, spatiotemporally averaged stocks. This approach fails to account for the reality that movement explicitly dictates the timing and location of ecosystem interactions. As habitat fragmentation increasingly restricts mobility, understanding the mechanistic link between animal movement and nutrient cycling is critical.

We address this gap with a novel Agent-Based Model (ABM) that integrates movement ecology with landscape-scale nitrogen (N) dynamics. Our model couples high-resolution GPS trajectories of red deer (*Cervus elaphus*) in the Italian Alps with spatially explicit land-use and NDVI data. By utilizing empirical data on herd sizes, metabolic rates, and activity patterns, we simulate how migratory versus resident tactics influence N redistribution. We compare observed nutrient flows against scenarios where migration is lost to quantify how movement behaviors modulate biogeochemical heterogeneity.

Our analysis reveals that red deer act as essential mediators of nitrogen flux across multiple scales. Locally, foraging behaviors drive net nitrogen transfers from grasslands into forest patches. At the landscape level, migratory herds facilitate both vertical (altitudinal) and horizontal nutrient exchange, effectively connecting distinct ecosystems and buffering against nutrient accumulation or depletion. Conversely, resident herds in fragmented landscapes concentrate nutrients, increasing the risk of localized eutrophication. Furthermore, we identify anthropogenic barriers, such as roads, as significant obstacles that decouple these historical nutrient flows.

We conclude by evaluating the economic consequences of severing these migratory pathways, arguing that conservation strategies must explicitly incorporate movement ecology to maintain essential ecosystem functions in human-altered landscapes.